POWER PLANT ENGINEERING

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New Plant of the Barber Asphalt Co.

FURNACES DESIGNED FOR BURNING COAL CONVERTED TO THE USE OF OIL BECAUSE OF COAL STRIKE

EARLY IN THE YEAR 1921 the Barber Asphalt Company started the construction of a new power plant to serve their refineries at Maurer, New Jersey. The old power house had burned down and it was of vital importance to get a new plant in service as soon as possible. there was not nearly enough to supply the normal needs of the new power plant.

To meet the emergency, the officials decided to install a temporary oil burning system to be used until the coal situation was relieved. Contracts were let and the work of installing this system was started immediately. This,

FIG. 1. VIEW IN BOILER ROOM, SHOWING OIL BURNERS ABOVE STOKERS

Due to labor trouble, however, construction work was delayed from time to time, and it was not until the spring of 1922 that the plant was finally ready for operation. But once more, trouble loomed up. As the reader will recall, it was just about at that time that the anthracite coal strike set in, and because the plant had been designed for burning anthracite coal, things assumed a serious aspect. There was some coal on hand, and a small amount was available from outside sources but of course, had to be done without interfering with the operation of the plant and progress was necessarily slow. The plant itself was only partly completed and the new alterations in piping and furnace construction, together with the hundreds of details to be looked after in the first few weeks of operation of the new power plant, taxed the perseverance of the engineering force to no small degree.

It was not until the early part of this year that the

finishing touches to the plant could be applied. The plant is now in full operation and with the exception of the oil refinery, supplies all of the company's properties in the vicinity of Maurer.

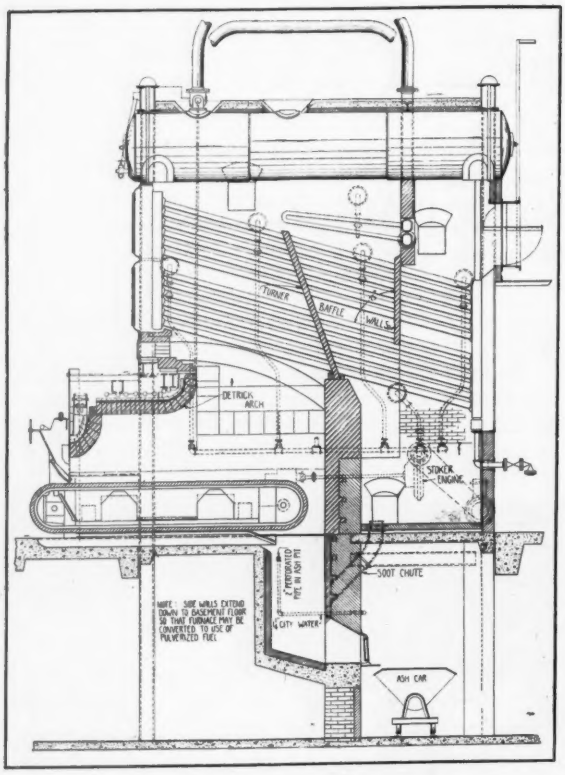


FIG. 2. SECTION THROUGH ONE OF THE BOILERS

It is of interest to note that the oil burning system is still being used. It was, as stated above, installed as a temporary measure to relieve the situation caused by the coal shortage, but the use of oil as fuel under the boilers has proved so satisfactory and so economical that they will continue to use it until the price of fuel oil increases sufficiently to warrant the use of coal again. With fuel oil at the present prices, it is found equally or more economical to burn oil than it is to burn coal. Then, too, there is to be considered the greater simplicity and ease of handling fuel oil.

Plant Has Both Railroad and Steamship Facilities

The plant is located on the Central Railroad of New Jersey, at Maurer, just north of Perth Amboy. Excellent railroad facilities are provided by the Central Railroad and the plant is equipped with docking facilities for ocean going steamships. Practically all of the raw material used is delivered direct by steamship.

For the refining of asphalt, a considerable amount of live steam is required. The boiler room is therefore an important part of this power plant, only a small percentage of the total installed boiler capacity being used for the generation of electricity. The power load varies between 100 and 500 kw. and the steam load from 500 to 2000 b.hp. Feed water used is city water. This is a soft water but is slightly acid, and is treated with soda ash to neutralize the acidity.

An exterior view of the power house with a portion of the coal storage pile at the right is shown in Fig. 14. The ash hopper, into which ashes from the furnaces is stored until its removal from the plant, may be seen directly to the right of the building. The two large tanks in the foreground are compressed air tanks, and the concrete structure seen at the extreme left, houses the transformers used for distribution of electrical energy throughout the plant. The building proper, as may be noted, is constructed of brick and is amply provided with windows thus insuring good natural illumination throughout. The radial brick stack, shown on the photograph, in 175 ft. high, 11 ft. 6 in. in diameter at the top, and 14 ft. 4½ in. at the bottom, these being inside measurements. It was built by the M. W. Kellogg Company of New York City.

Features of Boiler Room

Five 520-hp. water tube boilers are installed in the boiler room, with space for a future sixth unit which,

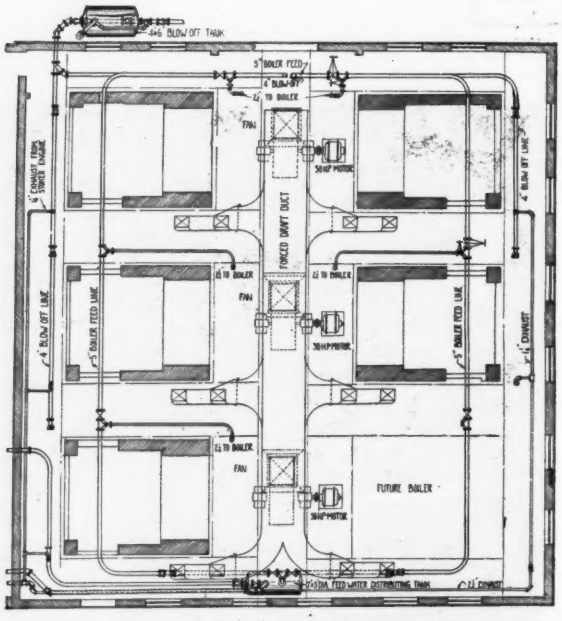


FIG. 3. PLAN OF BOILER ROOM BASEMENT SHOWING FEED WATER PIPING

when installed, will increase the total capacity from 2600 hp. to 3120. These boilers are arranged on opposite sides of the boiler room, with the firing aisle in between, as shown in Fig. 4.

Two of the boilers are old Babcock and Wilcox units and two are Aultman and Taylor units which had been in use at the old plant. The fifth unit is a new Babcock and Wilcox unit of the same design and size as the old ones. A cross section through one of the boilers is shown in Fig. 2. It is a three drum, three pass boiler set 11 ft. from the floor and connects to the uptake at the rear. Turner inclined baffle walls are provided, these being arranged so as to give a uniformly converging gas path towards the outlet to compensate for the decrease in volume of the gases as they cool off. The Foster superheater is installed between the tube nest and the steam drums, and is designed to give a normal superheat of 50 deg. F. Each boiler is equipped with a 10ft. 8⅝-in.

by 11-ft. Coxe chain grate boiler stoker, driven by a two-cylinder Acme engine. At the present time, however, these stokers are covered with a bed of fire brick and Hammel oil burners are installed above this bed.

A feature of these boilers, which may be of interest, is the fact that the side walls are carried through to the basement, so that if desired at some future time, the furnace may be converted to the use of pulverized fuel. In this event the stokers would be removed and the furnace volume thus greatly enlarged.

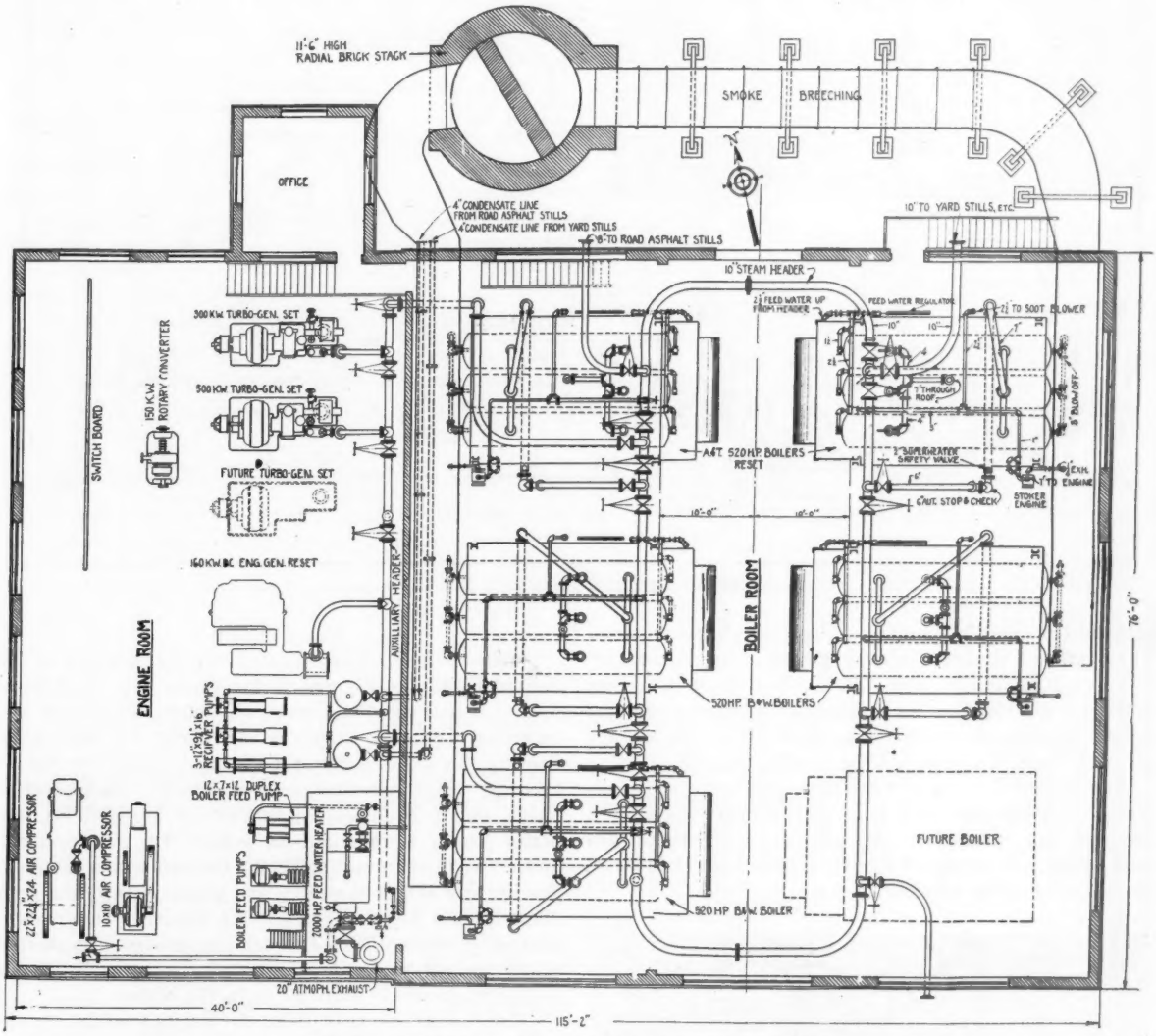


FIG. 4. GENERAL PLAN OF BOILER AND ENGINE ROOM

All furnaces are provided with Detrich suspended arches over the stokers and the boilers are fitted with Diamond soot blower units.

Ash is discharged over the rear end of the stoker into an ash pit fitted with a water spray and is removed through the ash pit doors in the basement. Soot and flue dust accumulating behind the bridge wall is swept into the coal chute through which it finds its way into the ash pit.

Forced draft is supplied to the furnaces by three motor driven, Green fuel economizer fans, all discharging into a common duct installed along the ceiling in the basement. Blower motors are Westinghouse, 30-hp., 440-v., 3-phase, 60-cycle, 37 amp. per terminal with a speed of 870 r.p.m. Air to the individual furnace is controlled by dampers in the feeder ducts, by operating levers from the boiler room floor. The forced draft fans are hand controlled, but the speed of the stoker engines is regulated by means of the Hagan system of automatic control. Shumaker Santry draft gages are installed, six being fitted to each boiler, four for the wind boxes beneath the chain grate stokers, one for the furnace above the fuel bed, and one for the uptake.

Coal and Ash Handling

Coal from railroad cars is delivered directly into a large track hopper, shown in Fig. 15, and is carried by means of a scraper conveyor running in a tunnel, to a bucket elevator, for delivery to the upper part of the boiler room, or to another scraper conveyor for delivery to the storage pile. The bucket elevator running to the upper part of the boiler house delivers the coal to another scraper conveyor which distributes it to the overhead bunkers. All coal handling equipment is of C. W. Hunt

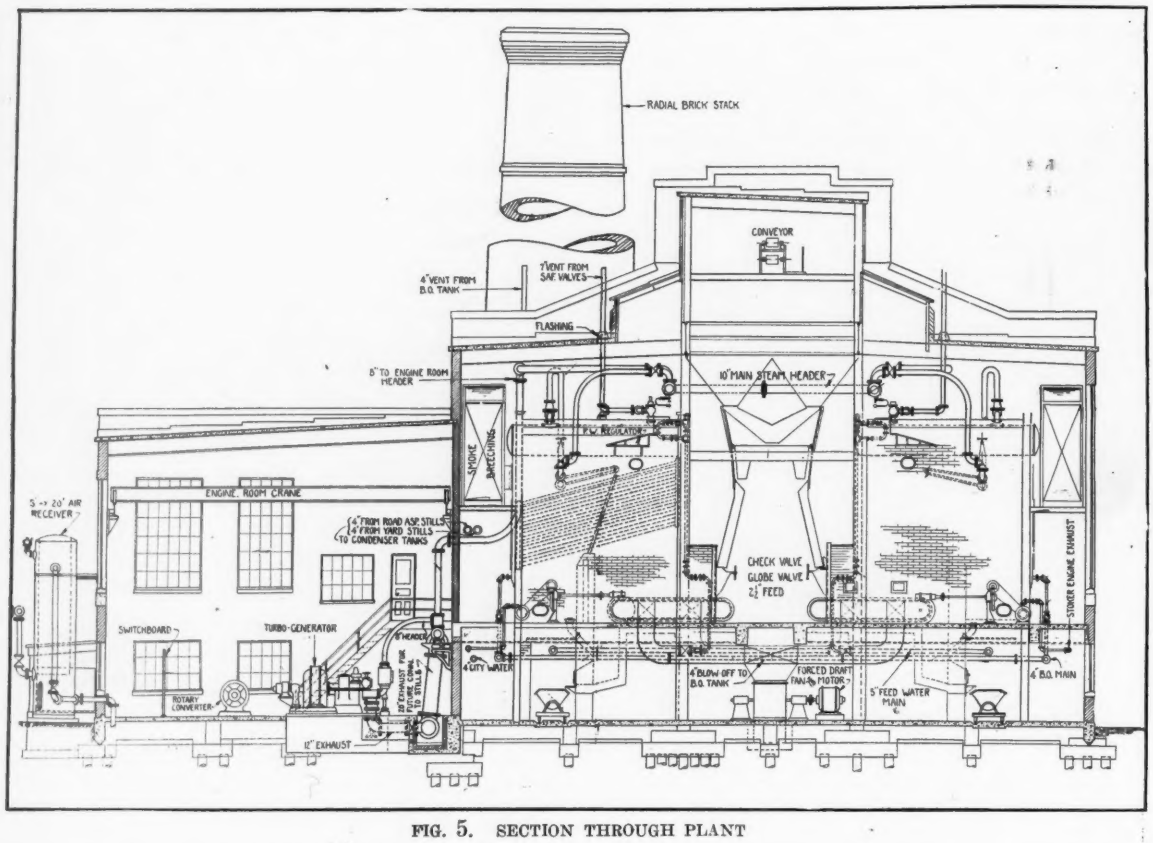


FIG. 5. SECTION THROUGH PLANT

manufacture and is operated entirely by electric motors. The overhead bunkers have a capacity of approximately 150 T. of anthracite coal. Richardson automatic coal scales are provided at each boiler for weighing the coal before delivery to the stoker hoppers. The coal storage pile outside of the plant is kept at about 3000 T.

Ash is pulled from the ash pits into small ash cars which deliver it to a skip hoist discharging into a 50-T. steel ash bin. This tank has sufficient capacity to take care of the ash produced during a period of 24 hr. with the plant running at peak loads.

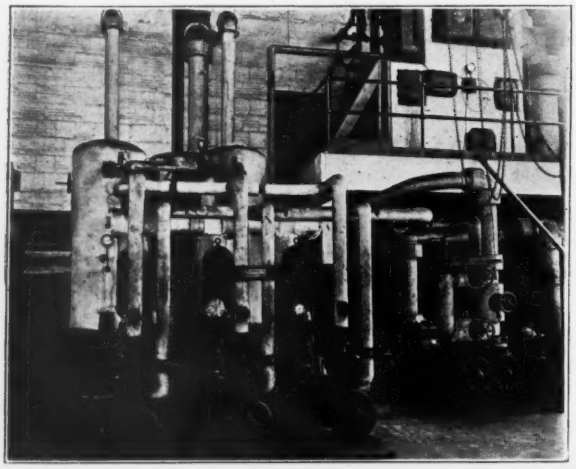


FIG. 6. VIEW IN ENGINE ROOM OF CONDENSATE AND FEED WATER PIPING

Feed Water

Make-up feed water is heated to a temperature of 215 deg. in a 2000-hp. Warren Webster open type feed water heater fitted with a Yarway V-notch meter and Lea recorder. Exhaust steam is used only for feed water heating, the exhaust being discharged to the atmosphere through a 20-in. Cochrane multiport, back-pressure valve, and a 20-in. cast iron exhaust head. This feed water heater is mounted on a platform in the engine room. If there is not sufficient exhaust steam available for heating the feed water, live steam is supplied from the auxiliary high pressure steam header. This is automatically accomplished through the agency of a thermostatic control valve, depending for its action upon the temperature of the feed water in the heater.

Condensate returns from the asphalt stills are also used as feed water. As this condensate is at a high temperature, a closed system is used and the condensate is returned to the two receiving tanks under 100 lb. pressure. These tanks are about 8 ft. in height and 3 ft. in diameter.

Three Davidson simplex pumps, size 12 by 9¼ by 16 in., take suction from the condensate receiving tanks and pump the water into the feed water distributing tank where it mixes with the make-up feed water before being delivered to the boilers. The Davidson condensate pumps are controlled by the water level in the receiving tanks by means of a chronometer valve in the steam line to the pumps.

Make-up feed water after being heated in the open heater is delivered to the distributing tank referred to above, by either of three feed pumps. Two of these are

3 in., 5 stage, Lea-Courtenay centrifugal pumps with a rated capacity of 100 g.p.m. under a 400-ft. head, at 1750 r.p.m. Both units are driven by 25 hp., 440 v. Westinghouse motors. The third feed pump is 12 by 7 by 12 in. duplex Worthington unit, fitted with a Foster governor.

From the feed water distributing tanks, the feed water is sent into the main feed line. This is a 5-in. line running entirely around the boiler room in the basement, forming a loop.

The discharge line from the motor driven feed pumps is fitted with an S. C. excess pressure relief valve, set at 170 lb. The function of this valve is to safeguard the pumps against an overload.

When the pumps are in operation and several of the Copes regulators shut off the supply of feed water to the boilers at the same time, an excess pressure will be created throughout the entire feed line. When the pressure rises above 170 lb, the excess pressure valve opens allowing the water to pass back to the pump suction until the valve again closes.

Two and one-half inch lines deliver water from the main feed line to the boilers as shown in Fig. 8. Copes feed water regulators control the water level in the boilers.

Boiler Fittings and Accessories

Each boiler is fitted with three 4-in. safety valves and three blow off valves. The latter discharge into a 4-in. main blowoff header connecting into a 4 by 6 ft. blow off tank outside the building.

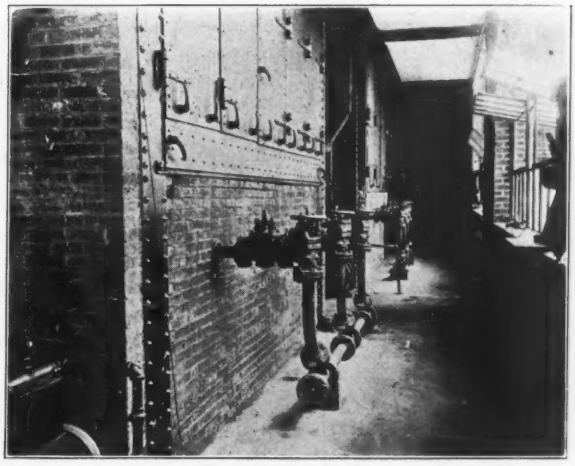


FIG. 7. BEHIND THE BOILERS, SHOWING BLOWOFF VALVES

Steam is measured by Republic flow meters, the indicating units of which are mounted on columns between the boilers. The integrating and recording elements of these meters are located on a board in the chief engineer's office.

As this board also contains other instruments used in connection with the boilers, we shall describe it here. This instrument board consists of four panels of marbleized slate, containing in addition to the steam flow meter elements mentioned above, the following instruments:

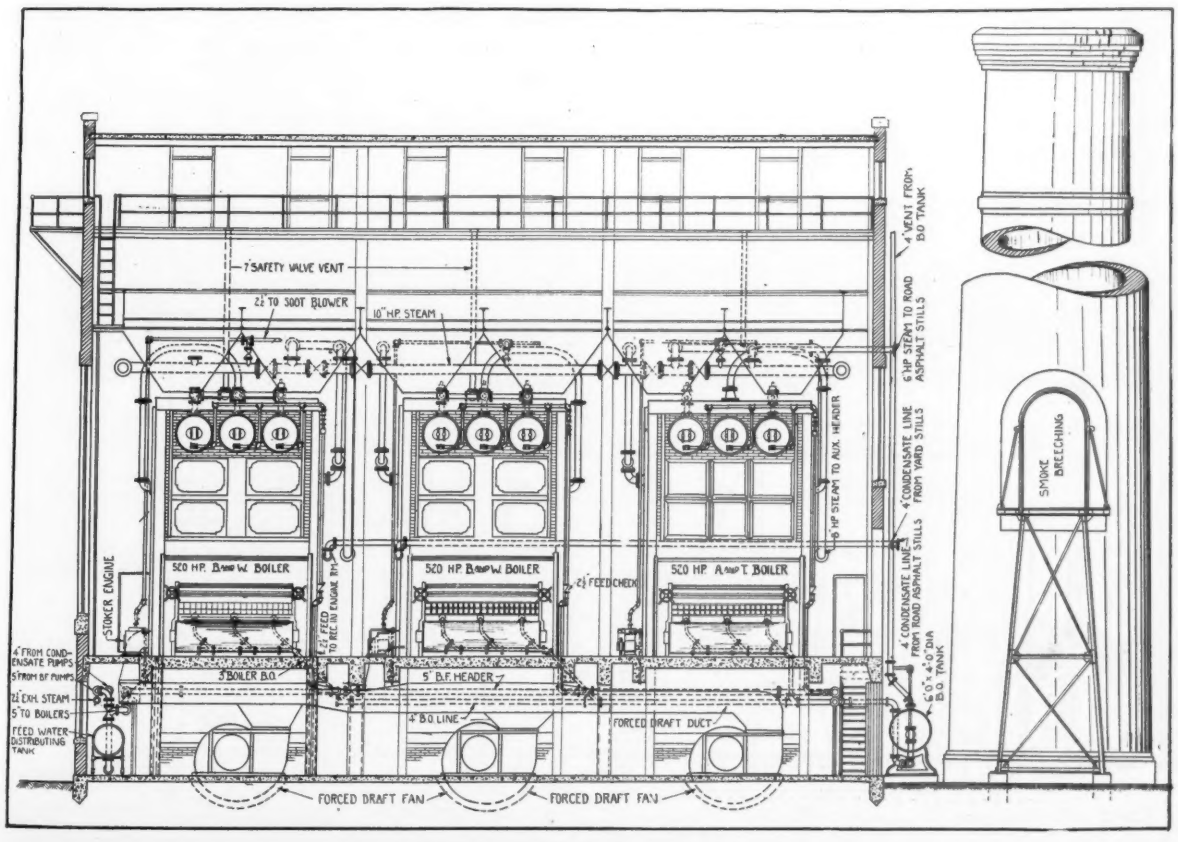

7" SAFETY VALVE VENT
2½" TO SOOT BLOWER
10" H.P. STEAM
4" VENT FROM B.O. TANK
6" H.P. STEAM TO ROAD ASPHALT STILLS
6" H.P. STEAM TO AUX. HEADER
4" CONDENSATE LINE FROM YARD STILLS
4" CONDENSATE LINE FROM ROAD ASPHALT STILLS
4" FROM CONDENSATE PUMPS
5" FROM B.F. PUMPS
12" EXH. STEAM
5" TO BOILERS
FEED WATER DISTRIBUTING TANK
STOKER ENGINE
2½" FEED TO REC. BO ENGINE
2½" FEED CHECK
5" BOILER B.O.
5" B.F. HEADER
4" B.O. LINE
FORCED DRAFT DUCT
FORCED DRAFT FAN
FORCED DRAFT FAN
SMOKE BREECHING

FIG. 8. ELEVATION, SHOWING BOILER FRONTS

FIG. 9. A CORNER OF THE ENGINE ROOM

2 Republic steam flow meters, one for the north engine room header and the other for the south engine room header.
3 meters, for outside steam feeder lines.
1 meter measuring water from the condensate pump.
1 meter measuring the water from the boiler feed pump.
4 Brown Instrument Co. recording thermometers, one on the main steam header, one on the condensate line from the stills, one on the feed water heater, and the fourth on the main boiler feed line.
1 Brown recording pressure gage, for recording the steam pressure in the main header.

A Mono CO_2 recorder is installed to record the composition of the flue gases.

Electric Generating Equipment

Electric generating equipment consists of two new turbo alternators and one old, engine driven unit. The two turbine units are Westinghouse single stage counterflow machines, one a 500-kw. and the other a 300-kw. unit. Both are geared sets with direct connected exciters, generating three phase, 60 cycle, alternating current at 2300 v. The turbines operate non-condensing, as the exhaust steam is required for feed water heating. The

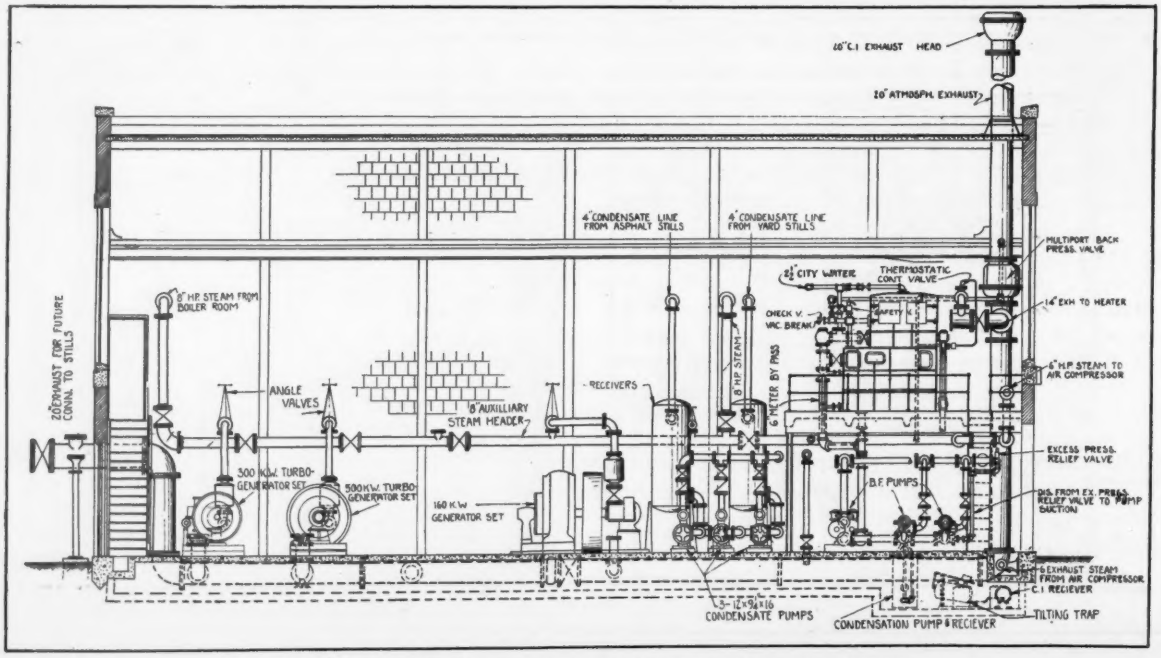

20" C.I. EXHAUST HEAD
20" ATMOSPH. EXHAUST
4" CONDENSATE LINE FROM ASPHALT STILLS
4" CONDENSATE LINE FROM YARD STILLS
MULTIPORT BACK PRESS. VALVE
2½" CITY WATER
THERMOSTATIC CONT. VALVE
14" EXH. TO HEATER
CHECK V. VAC. BREAK
SAFETY
8" H.P. STEAM FROM BOILER ROOM
20" EXHAUST FOR FUTURE CONN. TO STILLS
ANGLE VALVES
8" AUXILLIARY STEAM HEADER
RECEIVERS
8" H.P. STEAM
6" METER BY PASS
6" H.P. STEAM TO AIR COMPRESSOR
EXCESS PRESS. RELIEF VALVE
300 K.W. TURBO-GENERATOR SET
500 K.W. TURBO-GENERATOR SET
160 K.W. GENERATOR SET
B.F. PUMPS
DIS. FROM EX. PRESS. RELIEF VALVE TO PUMP SUCTION
6" EXHAUST STEAM FROM AIR COMPRESSOR C.I. RECIEVER
3-12"x9"x16" CONDENSATE PUMPS
CONDENSATION PUMP & RECIEVER
TILTING TRAP

FIG. 10. ELEVATION OF ENGINE ROOM PIPING AND EQUIPMENT

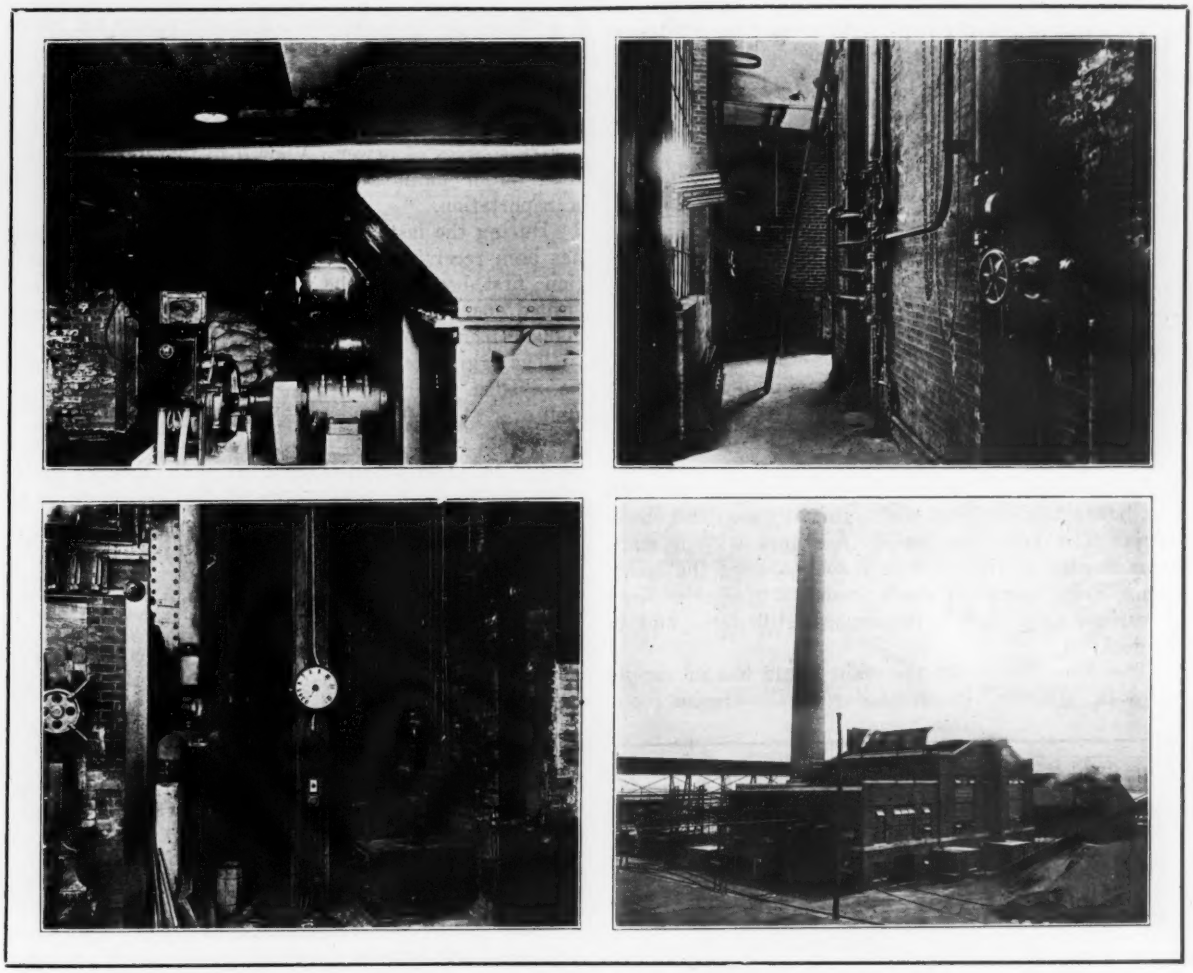
reduction gears effect a speed reduction of 6000 to 900 r.p.m., the latter being the speed of the generators. The engine driven unit referred to is an old direct current set, which was moved over from the old power house.

It consists of a 160-kw., 250-v. d.c. General Electric generator, driven by a 225-hp. Harrisburg engine.

In addition to the above, there is also installed a General Electric rotary converter, rated at 150-kw., 2300 v., a.c., 250 v., d.c., 1200 r.p.m. This is used to convert the direct current energy supplied by the engine driven unit to alternating current, which is standard throughout the plant.

Both air compressors discharge into two receivers located outside of the engine room, in which a constant pressure of 100 lb. per sq. in. is maintained by an Erie unloader on the electrically driven compressor and by an Erie pressure governor on the steam driven unit. Both of these regulating devices are made by the Jarecki Mfg. Co. of Erie, Pa.

Compressed air is used mostly for blowing out oil lines, but is also used for operating a number of automatic machine tools.



FIGS. 11 TO 14. VIEWS AT THE NEW PLANT OF THE BARBER ASPHALT CO.

Fig. 11. One of the Forced Draft Fan Drives. Fig. 12. At the Side of the Boiler, Showing the Soot Blower Valves. Fig. 13. Steam Flow Meters are Mounted on Columns Between the Boilers. Fig. 14. The plant from the Outside.

Compressed Air

Air is compressed by two compressors, one an old Ingersoll-Sergent machine, 22 by 22¼ by 24 in. with a capacity of 850 cu. ft., and the other a new Worthington-Laidlaw unit. The latter has a displacement of 250 cu. ft. per min. and is driven by a 50 kv.a., 440 v., 3-phase, 60 cycle General Electric synchronous motor. It is started as an induction motor and when up to speed and running as a synchronous motor, aids materially in maintaining a high power factor.

The air receivers are large steel tanks 20 ft. in height and 5 ft. in diameter.

Electrical Features

Electrical energy is controlled and distributed by an 18 panel, black slate switchboard, fitted at one end with a swinging panel on which are mounted the frequency meter, synchroscope and a.c. voltmeter. Fifteen of the panels are for alternating current service and the remaining three for direct current service.

Current for distribution throughout the plant is stepped down by means of two sets of transformers of 150 kw. each. These are located outside of the engine

room on the ground level under a concrete structure, fitted with guards to prevent accidental contact with the high tension leads. From the transformers, the conductors are carried to a nearby distribution tower from which distribution throughout the plant is effected by overhead lines. Distribution is mostly at 440 v. in this

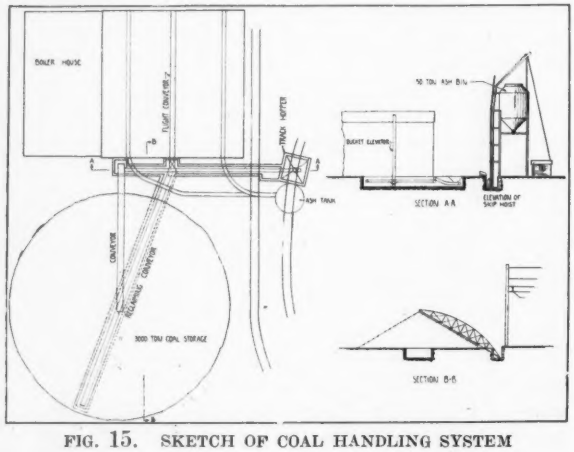


FIG. 15. SKETCH OF COAL HANDLING SYSTEM

plant, but 2300 v. is used to transmit current to the roofing plant some 2 mi. away.

Miscellaneous Details

Steam is taken from the boilers at 150 lb., through 6 in. boiler headers fitted with automatic stop and check valves. The individual headers feed into a 10 in. main steam header in the form of a loop around the boiler room. From this main steam header, a number of lines of various sizes lead to the asphalt stills, etc., and to the dock.

Two 8-in. lines from the main steam header supply the 8 in. auxiliary steam header in the engine room,

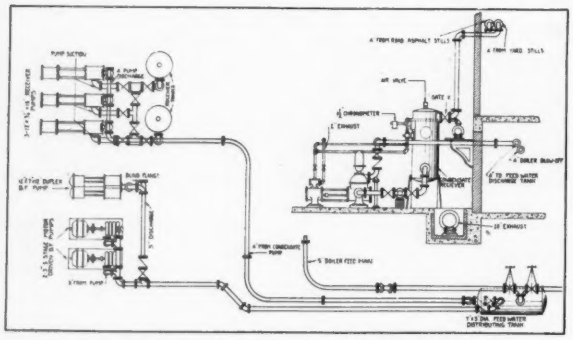


FIG. 16. DETAILS OF FEED WATER SYSTEM

which in turn supplies all of the steam using apparatus in this room. The two turbines are supplied through 5 in. lines with a separator installed immediately ahead of the throttle valve. Water drained from this separator is sent back to the boilers by Kieley and Mueller steam traps. The two generators are equipped with Richardson multiple oil filters.

All valves over 2½ in. are Crane while all under 2½ in. are Lunkenheimer. Ballwood joints are used in all large piping.

The power plant was designed by Lockwood Greene & Co., engineers of New York City, and Levering and Garrigues were the general building contractors.

In concluding this article we wish to extend credit to John H. Weller, general manager of the Barber Asphalt Co., and to Lockwood, Greene & Co. for assistance rendered in gathering the data which forms the basis of this description.

Railroad Power Plant Is Factor in Transportation

ONE HUNDRED AND ONE power plants are maintained by the Southern Pacific Railroad System supplying steam, air, water, oil or power essential to practically every service. Failure of the power plant means failure of other operations, or the substitution of temporary sources of power. Viewed in this light, the railroad power plant rises in importance as a factor in transportation.

During the last few years, the railroad power plant has been receiving an ever-increasing amount of attention; first, because of the vital necessity for its uninterrupted operation, and second, because of its very appreciable consumption of fuel.

The aggregate fuel bill for power plants on the Pacific System of the Southern Pacific Company is now well over $1,000,000 per yr. When it is realized that, in individual plants, from 5 to 35 per cent of fuel burned may be saved by the intelligent use of the modern equipment installed, the possibilities of fuel conservation in this connection becomes apparent.

All of the larger plants of the Southern Pacific are being equipped gradually with oil meters, water meters, and thermometers. These instruments furnish the means for determining the performance of stationary plants, and serve as a guide to more efficient operation. Progress in efficiency is dependent directly upon the accuracy of the information available for study.

In order to determine the best in stationary power plant practice, the fuel conservation committee of the company has conducted numerous tests of boiler room equipment and accessories. This information pertaining to boilers, furnaces, burners, feed water heaters, dampers, valves and packing, has been given to all divisions. Many power plants now show the effects of applying these improvements.

U. S. Civil Service Commission announces an examination for observer and computer in gas analyses. The examination will be held throughout the country on Aug. 8. It is to fill a vacancy in the Bureau of Mines, at Pittsburgh, Pa., and vacancies in positions requiring similar qualifications, at entrance salaries ranging from $1320 to $1620 a year, plus the increase of $20 a month granted by Congress. Applicants must have been graduated from a 4 yr. high-school course, and in addition, they must have completed 3 yr. of a mechanical engineering course in a college of recognized standing, or, in lieu of each year of such college course, they must have had 6 mo. experience in observing and recording temperatures, pressures, and other observations on boiler trials, including experience in analyzing flue gases completely. Competitors will be rated on practical questions and computations in gas analysis and boiler tests, and education, training, and experience.

Standards in Power Plant Piping Practice

COMMERCIAL PRACTICE VARIES SO THAT PIPING STANDARDS MAY BECOME CONFUSING. THIS ARTICLE POINTS OUT MANY OF THE PRACTICES WHICH MUST BE WATCHED FOR

THROUGH the co-operation of manufacturers, standards for piping have been well established; in addition, current practice has also brought about certain ways of specifying piping which should be well understood. The lack of knowledge of standards and current practice may lead to inconvenient delays and needless expense.

Under no condition should a deviation be made from standard practice without a careful study having been made and a full understanding reached of all the local conditions which prevail.

Pipe suitable for power plant service is generally classified as wrought iron or steel; the latter is more commonly used and should wrought iron be desired, it will be necessary to specify it as genuine wrought iron pipe.

Commercial pipe sizes are always stated in terms of the nominal inside diameter up to and including 12 in. Above 12 in. internal diameter, the size is based on the outside diameter and the thickness of metal must be specified. There are three weights or strengths of pipe used in power plant work; these are known as "standard," "extra strong" and "double extra strong." In each case the diameter of the outside of the pipe is the same for a given size; therefore the extra weight of metal is added to the inside, thus reducing the nominal inside diameter of the pipe. This means then that a 3-in. standard weight will have a greater carrying capacity than a 3-in. "extra strong" pipe; likewise, a 3-in. "double extra strong" pipe will have less carrying capacity than the 3-in. "extra strong" pipe. Based on the thickness of standard pipe as 100 per cent, the thickness of extra strong pipe will be 140 per cent, and that of double extra strong pipe will be 280 per cent. Pipe 8, 10 and 12 in. inside diameter may be purchased in various weights; it is necessary, therefore, to specify the weight desired.

Pipe steel averages about 57,000 lb. per sq. in. ultimate strength. The relative strengths of steel pipes based on numerous tests are given by Marks, as follows: Butt welded steel pipe, 73 per cent; lap welded steel pipe, 92 per cent; and for seamless steel tubes, approximately 100 per cent. Tests on commercial tubes and pipes give the following average twisting pressures in pounds per square inch; butt welded steel, 41,000; lap welded steel, 52,000; and seamless steel, 62,000. As a general rule it may be stated that the factor of safety for steam piping should not be less than 6.

Standard weight pipe comes in random lengths of 18 to 20 ft; butt welded in sizes 8 to 3 in., inclusive, and lap welded, 1½ to 12 in., inclusive. Extra strong pipe comes in random lengths of 12 to 20 ft., butt welded in sizes 8 to 3 in., and lap welded 1½ to 12 in. The same trade practice is followed in furnishing double extra strong pipe as for extra strong pipe. Large lap welded steel pipe, 12 in. and over, can be obtained in random lengths 15 to 20 ft; double length pipe 32 to 40 ft. may be obtained for all grades of pipe. Standard weight pipe is carried in stock with both ends threaded and each length is fitted with one coupling, the measured or shipping length will be measured over the coupling. Extra strong and double extra strong pipe is regularly supplied with ends not threaded and couplings must be purchased separately. Outside diameter pipe of 5/16-in. wall thickness or less cannot be threaded satisfactorily.

Wrought pipe, in the larger sizes and where higher pressures are employed, is connected by means of flanged couplings, which are made up in the following ways: welded, shrunk, Van Stone and screwed; their relative cost is as listed, the welded type being the most expensive. In making the welded joint, a forged steel flange is welded to the pipe end; this is done with special machinery so that the results are essentially a hammer weld. The pipe should protrude beyond the face of the flange so that a cut may be taken to finish the pipe flush with the flange face. This type of joint is suitable for high pressure work.

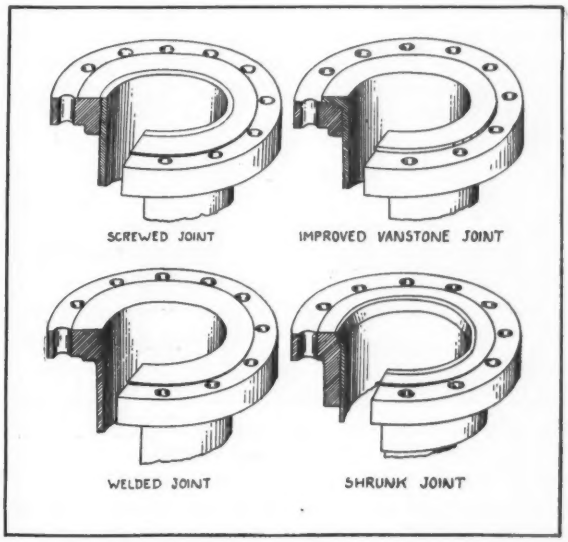


FIG. 1. EFFECTIVE METHODS OF CONNECTING FLANGES TO WROUGHT IRON OR STEEL PIPE

The shrunk flange was formerly used extensively for high pressure work before the advent of the Van Stone joint which is made by flanging the pipe after loose flanges have been slipped on. With modern methods of manufacture, the Van Stone joint is made with additional metal at the turn and the water pocket right at the joint has been eliminated. This type of joint greatly facilitates erection because the flanges can be easily turned to match bolt holes, it is a first-class commercial joint which is dependable, and suitable for high pressures. Pipe manufacturers have recently developed a method for Van Stoning genuine wrought iron pipe.

Screwed flanges, when properly made up, are suitable for medium steam working pressures. Both the pipe and the flange must be accurately threaded, after which the flange should be screwed on until the pipe projects beyond the flange face, a cut should then be taken to

bring the flange and pipe flush and on the true center axis of the pipe. This type of joint may be made in sizes up to and including 12 in. although it is not recommended in the larger sizes.

Flanged faces are finished in the following standard ways: plain, straight face, corrugated face, raised face with smooth finish, male and female faces, tongue and groove, and ball shaped flanges with inserted rings for ground joints. The plain face type of joint is faced flush and is adaptable to pressures below 125 lb. with either full face or ring gasket. Relatively thick gaskets are best adapted to this kind of joint because then sufficient pressure may be exerted on the gasket to hold the joint tight before the outside edges of the flanges meet. A ring gasket will make just as tight a joint as the full face gasket provided that it is properly made and installed. The ring gasket will save on material and will require less pulling up on the bolts.

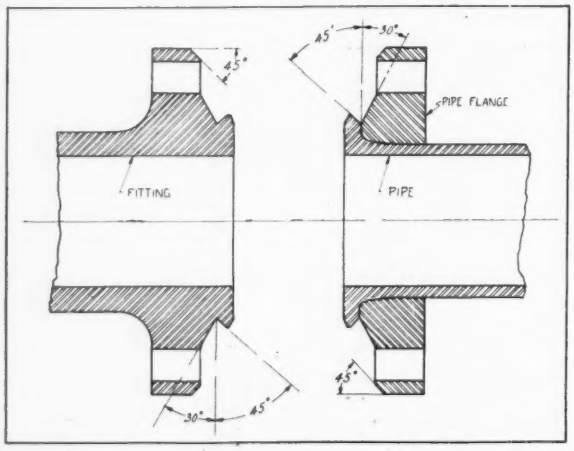


FIG. 2. SARGOL FLANGED COUPLING IS WELDED FOR STEAM TIGHTNESS

Corrugated faced flanges allow the use of rather heavy gaskets and tend to hold the gasket from blowing out. This type of joint is not extensively used for steam service. The raised face joint with smooth finish is by far the most used type of joint today. The flange face is generally raised about 1/16 in. between the pipe bore and the inside edge of the bolt circle; the ring type of gasket is used with this type of joint. This is by far the most common and satisfactory type of joint for high pressure steam. Its particular advantages are that it eliminates all mating of flanges, as they are all male; any valve, fitting or piece of pipe may be removed from the line without springing the line apart; and the gaskets are automatically centered by coming in contact with the bolts.

Male and female, and tongue and groove faces effect a saving of gasket material due to the correspondingly smaller ring required and, further, they hold the gasket securely in place. These faces are entirely satisfactory for high pressures, but offer the disadvantage that the joint must be sprung to insert or drop out a pipe length or fitting. The ball shaped flange with inserted noncorrosive rings is coming more into use, no gasket is necessary and the ball joint allows a reasonable misalinement of the pipe; it is similar to many screwed unions.

For extremely high pressure and superheats a modification of the Van Stone joint has been developed which is known as the Sargol joint. It differs from the Van Stone in that the inside edges of the pipe flange are scarfed so that they may be welded, thus eliminating gaskets, the loose flanges are bolted up in the usual way to take all strain from the weld. Due to the damage to the metal in upsetting bolt heads, it is recommended that stud bolts be used where first-class material is required.

Care must be exercised in the selection of pipe for bends. Crane Co.'s recommendations are shown in the accompanying table:

THICKNESS OF PIPE FOR VARIOUS BENDS

UP TO 125 LB. WORKING PRESSURE

Radius	Pipe Size	Pipe
4 to 5 diameters	7 in. and smaller	Extra strong.
	8 in. and larger	½ in. thick.
Over 5 diameters	7 in. and smaller	Full weight.
	8 in.	28.55 lb. per ft.
	10 in.	40.48 lb. per ft.
	12 in.	49.56 lb. per ft.
	14 in. to 16 in., inclusive	5/16 in. thick.
	18 in. to 22 in., inclusive	⅜ in. thick.
	24 in. to 30 in., inclusive	7/16 in. thick.

125 LB. TO 250 LB. WORKING PRESSURE

4 to 5 and 6 diameters	7 in. and smaller	Extra strong.
	8 in. and larger	½ in. thick.
Over 6 diameters	7 in. and smaller	Full weight.
	8 in.	28.55 lb. per ft.
	10 in.	40.48 lb. per ft.
	12 in.	49.56 lb. per ft.
	14 in. to 16 in., inclusive	⅜ in. thick.
	18 in. to 22 in., inclusive	7/16 in. thick.
	24 in. to 30 in., inclusive	½ in. thick.

125 LB. TO 350 LB. WORKING PRESSURE

4 diameters and over	7 in. and smaller	Extra strong.
	8 in. and larger	½ in. thick.

It is preferable to make bends of one length of pipe, where this is impossible flange couplings may be used provided that they are located where they will not take the hinge action stresses due to expansion of the pipe. For moderately high pressures, welds may be used where it is necessary to splice lengths of pipe for bends, provided that the weld is located as previously stated for flanged joints and that the weld is reinforced by a ring welded over the joint. The welds should be subjected to a pressure and hammer test after annealing.

Practically all manufacturers now stamp or cast their valves and fittings with a designation of the material and service pressure recommended. The pressure designated is the steam working pressure and not the water or test pressure. One manufacturer states that low pressure, standard and machined valves and fittings will stand a water working pressure 40 per cent greater than the steam working pressure on sizes 12 in. and smaller, and sizes 14 in. and larger will stand 20 per cent greater water working pressure. The foregoing also applies to extra heavy globe valves and screwed fittings and all extra heavy valves and fittings larger than 8 in. Extra heavy gate valves, check valves and flanged fittings will stand 400 lb. water or natural gas working pressure on sizes 8 in. and smaller when the temperature does not exceed 100 deg. F.

When making the selection of a valve, it should be kept in mind that it must be so constructed and of the proper metal and weight not only to withstand the

steam pressure, but also the weight of the pipe and the strains imposed upon it due to pipe expansion. It should be possible to repack all valves when under pressure and it will be well for the prospective buyer to give careful consideration to interchangeability and renewal of valve parts.

All valves 6 in. and larger should be specified with a bypass, this bypass to be of the same general construction as the valve to which it is attached. Drain bosses, drilled and tapped, should be specified where required, both on valves and fittings. Screwed valves and fittings are not generally recommended for steam service in sizes over 6 in. The bypass on globe valves is located on the right-hand side looking at the inlet end, that is the end with the passage under the disc. The bypass on angle valves is located on the back, that is, opposite the outlet. Where high velocities prevail, modern practice

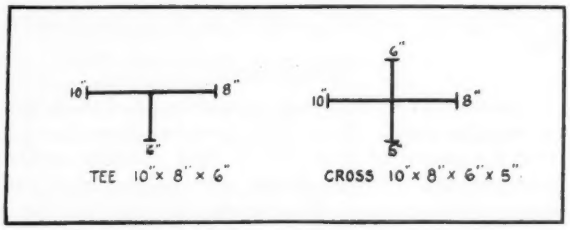


FIG. 3. REDUCING FITTINGS MUST BE DESIGNATED IN A CERTAIN RECOGNIZED ORDER

calls for over-sized ported globe valves; this overcomes the difficulty which would be experienced in operating gate valves under that condition.

When chain operated valves are required the wheel and chain must be specified and the length of chain given. Gear operated valves must be specified and accompanied by an accurate sketch showing actual conditions of installation and operation. Motorized valves are more or less special and should be covered by complete specifications.

Expansion joints are not packed unless so specified in which case the style and kind of packing must be stated. Bases and side outlets on both the single and double type of expansion joints are generally special. Bases or anchorages are not drilled or spot faced unless so ordered.

It is generally accepted as standard practice that all standard flanged valves and fittings be regularly shipped with plain faces, whereas medium and extra heavy valves and fittings will be regularly furnished with faces raised 1/16 in. between the bore and inner edge of bolt holes; a change from these standards will call for an extra charge.

All flanged valves and fittings are furnished regularly not drilled; drilling and spot facing must be specified, for which an extra charge is made. All drilling will be in accordance with the American Standard with bolt holes ⅛ in. oversized and with the bolt holes straddling the center lines. Cast steel companion flanges when ordered faced and drilled will generally be spot faced at no extra charge; bolts and gaskets will not be furnished with companion flanges unless so ordered. Flange unions come faced and drilled and with bolts; gaskets, however, are not furnished unless specified.

Companion flanges must not be confused with flange unions which are lighter and have a smaller diameter and bolting circle, and also lighter bolting so that they cannot be bolted to flanged valves or fittings.

Flange diameters, bolt circles and distance face to face of extra heavy valves and fittings are greater than the corresponding dimensions of standard valves and fittings, therefore they are not readily interchangeable.

Orders for side outlet elbows should specify whether the outlet is to be on radial or intersecting center lines. Single sweep tees are not made with side openings larger than the run. Orders for eccentric tees (screwed fitting) should be accompanied with a sketch showing the exact position in which the fitting is to be placed.

When reducing fittings have more than two openings for pipe connections, it is necessary to specify these openings in a certain recognized order. A reducing tee is denoted by the run, first beginning with the larger opening and ending with the side outlet, as shown in the sketch. The tee is designated as 10 by 8 by 6 in. and the reducing cross as 10 by 8 by 6 by 5 in. Bullhead tees are specified in the same manner as reducing tees. Reducing flanges are specified by first stating the pipe size which is to screw into the reducing flange, and then stating the diameter of the flange, which will be the same as the companion flange with which it must match up.

General notes on the American Standard for flanged fittings are as follows:

Standard and extra heavy reducing elbows carry same dimensions center to face as regular elbows of largest straight size.

Standard and extra heavy tees, crosses and laterals, reducing on run only, carry same dimensions face to face as largest straight size.

Size of all fittings scheduled indicates inside diameter of ports, except for extra heavy fittings 14 in. and larger, when the port diameter is ¾ in. smaller than nominal size.

Twin elbows, whether straight or reducing, carry same dimensions center to face and face to face as regular straight size tees and ells.

Side outlet elbows and side outlet tees, whether straight or reducing sizes, carry same dimensions center to face and face to face as regular tees having reductions.

Bullhead tees or tees increasing on outlet will have same center to face and face to face dimension as a straight fitting of the size of the outlet.

Tees and crosses 9 in. and down, reducing on the outlet, use the same dimensions as straight sizes of the larger port. Sizes 10 in. and up, reducing on the outlet, are made in two lengths, depending upon the size of outlet.

Laterals 3½ in. and down, reducing on the branch, use the same dimensions as straight sizes of the larger port. Sizes 4 in. and up, reducing on the branch, are made in two lengths, depending upon the size of the branch.

The dimensions of reducing flanged fittings are always regulated by the reductions of the outlet or branch. Fittings reducing on the run only, the long body pattern will always be used.

Y's are special and are made to suit conditions.

Double-sweep tees are not made reducing on the run.

Uniform Costs for Power Plants---III

DISTRIBUTION OF FIXED EXPENSES; INTEREST AND DEPRECIATION IN PLANT COSTS. BY ALFRED BARUCH

IN ANY system of costs for power plants the fixed expenses are those expenses which do not vary with operating conditions. They are of such nature that they may not be charged directly to a department but must be distributed on some basis which will be equitable and just for all departments. These expenses will naturally vary with different plants, but as a general rule they may be classified as follows: Heat, light, depreciation, insurance, taxes, interest on plant, investment and general expense. Analysis is made of the items of cost that go to make up these individual expenses just as in the case of the current expenses. The basis of distribution will be stated in each case. In a plant that uses steam to generate electricity, heat may be bought from the boiler department and the cost can be determined on one of several bases, such as, radiation, surface, diameter and number of pipes, etc. The cost of the heat would be the same proportion of the total boiler room expense as the quantity of steam diverted for this purpose is of the total steam generated.

DISTRIBUTION OF HEAT EXPENSE

Heat is usually distributed on the basis of floor space occupied. In order to illustrate the operation of this principle, a plant is considered here whose total floor space consists of 12,000 sq. ft., distributed in the following manner:

Boiler—1500 sq. ft., equals 12½ per cent.

Operating Department—1800 sq. ft., equals 15 per cent.

Repair Department—2700 sq. ft., equals 22½ per cent.

Meters Department—2500 sq. ft., equals 21 per cent.

General expense—3500 sq. ft., equals 29 per cent.

General expense in this case covers office buildings, hall-ways, garage, and other parts of the plant which do not belong to any one department.

LIGHT

Light is charged on the average monthly consumption and is distributed to each department on the basis of meter readings, if meters are used, or else on the average consumption of each department. Then it is based on the number of lamps, the wattage of each lamp and the number of hours the lamp is in use. For a power plant to be without meters would be a little unusual, but there are some who do not have them for their purposes and in that case, the light must be distributed on some such basis as is given in the example below:

DISTRIBUTION OF LIGHT EXPENSE

Boiler room—10, 100-watt lamps × 1 = 1000 kw.-hr. = 15.2 per cent.

Operating Department—20, 100-watt lamps × 1 = 2000 kw.-hr. = 30.4 per cent.

Repair Department—30, 100-watt lamps × ⅓ = 1000 kw.-hr. = 15.2 per cent.

Meter Department—42, 100-watt lamps × ⅓ = 1400 kw.-hr. = 21.2 per cent.

General Expense—24, 100-watt lamps × ½ = 1200 kw.-hr. = 18.2 per cent.

In the preceding it is assumed that the boiler and operating departments use every lamp for 24 hr. continuously. The repair and meter departments operate only 8 hr. per day, and therefore use their lamps only one-third of the time, on a day's basis. The rest of the plant which is covered by general expense uses its lamps only one-half the time, or 12 hr. out of 24, and therefore, its consumption per hour is divided by two, so as to put the actual consumption on an even basis throughout. In other words, one hour of actual use is taken as the basis for distribution. If a department uses its lamps only 12 hr. out of 24, that is equivalent to using the lamp only one-half hour out of every possible hour, therefore the total consumption possible per hour for this lamp, is divided by two, in order to arrive at the actual consumption.

DEPRECIATION

Investments in buildings, machinery and equipment are wasting assets. They must therefore be replaced by other equipment or by a reserve fund which is accumulated through charges against the individual departments on the basis of the original cost plus the cost of all accessories. The rates used for different types of equipment is so varied that it cannot be given here. A complete table of depreciation is shown in the latter part of this article.

Depreciation is a charge that should be made to each individual department whenever possible. But if this is done, this policy must be consistent throughout the plant. This is a very difficult thing to do. Therefore, the usual procedure is to apportion depreciation to each department according to the value of the equipment it contains. The same would hold true for taxes and the method of distribution would be practically the same; that is, the taxes would be distributed on the value of the buildings and equipment in each department.

INSURANCE

Workmen's compensation insurance is distributed on the basis of the number of men in each department, or on the basis of the payroll in each department, since in many states the insurance is charge at so much per $100 wages. Interest on plant investment must be distributed according to the value of the equipment in each department and according to the value of the Building Housing Department.

It is absolutely necessary to include interest on plant investment in the cost since it is necessary to insure a definite return on the total investment over a normal operating period regardless of general conditions. From the cost-keeping point of view, it is necessary to include interest on investment since this interest often acts as a substitute for rent and sometimes as a substitute for labor costs as when a mechanical stoker is installed to replace a man.

The question of interest on plant investment has aroused so much debate that it is necessary to make an analysis of the arguments for and against the inclusion of interest in plant cost. It might be said, in passing, that this discussion is not concerned with the position

that theoretical economists take with reference to the proper deductions from the revenue, but only with the actual costs as they exist for a power plant, regardless of theory. The problem has to do with interest as part of the cost and not with the question of charging or not charging interest. That there is a question at all in the minds of the operators as to the place of interest in cost is due to a curious confusion of interest with profit. Profit is a residuum—what is left after all expense and charges have been paid off. It is the reward society pays a business man for taking the risk of engaging in business. He could avoid the risk by investing his money in bonds that are amply secured against loss by proper collateral. The man who invests his money in this way gets a fixed return. The man who operates a power plant is subject to a very uncertain return.

Why Interest Must Be Included

It is true that the operator cannot govern the price by including interest in his cost and that the mere fact of charging interest to the cost does not mean that he will get it back, but neither does charging salary or rent in the cost mean that he will get them back. That is the risk that he takes. As a reward he may get much more than the interest on his investment. The extra return is the profit.

It is necessary to charge interest into the cost whether the money is borrowed or not. The only difference between a man who borrows money to run a business and the one who does not is that the latter has sufficient funds to operate his plant without going outside for capital. The man who has borrowed money which fails to earn a return for any length of time, at least the interest on the investment, will be declared bankrupt. The man who puts his own money into the business will be allowed to stay on even though the business is insolvent; but it is conceivable that even this man will come to a point where his own money gives out and he may have to borrow money to continue, in which case, he would certainly have to charge the interest on the borrowed money to costs before he could declare a profit.

Everyone will agree that a man should charge the rent into his costs whenever he rents or leases the grounds and the building on which his plant is situated. This rent is only another form of interest. If a man may charge rent to his cost, why can he not charge interest?

Interest is a part of the selling price. It must be taken into account at some point to show whether the return on the investment is equal to the current rates of interest or not. If it is not, then it would pay the invester to take his money out of the business and put it into interest-bearing bonds. He himself could go to work for someone else at a salary, assuming for the sake of argument that he could demand the same salary elsewhere that he pays himself. Since interest must be included in price the only question is as to the proper place to apply the charge. If a man leaves interest out of his cost estimates altogether, but adds it to the profit, he may meet with difficulties in the payment of his income tax. The only other place for interest is in the indirect expense.

Closer examination of interest reveals the fact that it is almost inseparable from plant costs. It has an important bearing on production costs when they form the basis for prices. Interest in plant burden serves to control labor, material and the burden itself. It is an index to the plant policy on methods of operation.

Suppose a man is carrying a large quantity of coal on hand. If by planning his work carefully he can reduce the supply to half its bulk, he will have reduced his investment in it to half its size. That is, let us say the original quantity was worth $20,000 and by this method he had reduced his investment in coal to $10,000. He has now released $10,000 for other operations and he has saved the interest on $10,000 so far as coal is concerned. This saving is a reduction in operating costs.

Labor costs are affected in the same way. Suppose a man takes into consideration the purchase of mechanical stokers to replace the hand stokers he now employs. He would be induced to make this change in order to save the labor cost, necessitated by the present method. An offset to the saving of labor cost would be the interest on the money invested in the equipment; that is, the question here is not one of eliminating an element of the cost altogether, but of substituting one cost for another because the former is the lesser of the two.

In the cases just cited, interest on the investment becomes the alternative of two items whose position in the cost calculation cannot be doubted. Where machinery is substituted for labor, interest on the investment takes the place of direct labor cost.

Closely associated with the question of interest is the matter of depreciation. Interest provides for a return on the investment of capital. Depreciation reserves provide for the replacement of capital as the assets shrink in value. Neither should be omitted from the estimates of costs, yet both often are with the results that profits are declared which are really reductions from the capital, both principal and interest.

Depreciation Covers Shrinkage of Capital

Capital values change. Everyone knows that a machine bought new cannot be sold even a week later for the original purchase price. This does not mean that the machine has lost any of its efficiency; merely that its market value has been reduced. In case a sale is necessary, the capital assets as represented by this machine have shrunk. This loss can be made up only by sufficient earnings. These earnings cannot be forecast nor could provision for them be made unless depreciation is properly represented in cost. A man may feel that he bears these various factors in mind in adding on his profit but very often he overlooks them altogether. The best way to replace depreciated assets is through a reserve fund built up by charges included in the burden. The fund that accumulates as a result of this charge is represented on the liability side of the balance sheet as a reserve for depreciation. There are several methods for handling this fund. Some men lend this money out at interest and draw from it when a new machine is bought to replace the old and discarded equipment. Others prefer to use it as a part of the operating capital and so draw as the occasion arises. Depreciation is intended to replace such losses as are due to natural wear and tear. It may be sub-divided into several classifications.

First among these is the natural wear and tear. This is the same deterioration that goes on despite of repairs and replacement. It is the wasting that is due to you.

A second type is decay. For example, the boiler pipes may rust away until they are too thin to be used. The third type is due to neglect. This is not always due to carelessness or indifference. Sometimes an operator wishes to replace the equipment with a new machine and he will let the old one run down until it is useless without making any repairs or alterations. Equipment may also depreciate due to obsolescence. The invention or discovery of a new machine that saves costs may necessitate the discarding of the old one in order to meet competitive conditions.

In any calculation of depreciation as charged off each year, the starting point is the valuation of the equipment. After equipment has been put to use, the original cost no longer applies and the current market value as a secondhand machine must represent the machine, in the assets. The original cost of the machine is the purchase price plus freight and cartage charges. Machines are usually shipped knocked-down and it is necessary to erect and assemble them into place after they are delivered. The cost of erection should not be added to the original cost of the machine, since, in the event the machine is sold, the erection cost can never be recovered. The erection cost should be charged off as soon as possible, although it may be advisable to spread this charge over a whole year. The method of determining the rate of depreciation varies with conditions and to the extent the management is developed along scientific lines. There are two established methods for finding the rate of depreciation. First is the schedule rate method and the second is the flat rate method.

With the schedule rate method the reserve necessary is calculated by determining the schedule of depreciation on the basis of the expected life of the machine. Let us suppose a mechanical stoker costs $1000 originally, and is expected to be of service for 10 yr. At the end of that time, the scrap value of the machine will be $100. There remains, therefore, $900 to be distributed over 10 yr., which gives us a rate of $90 per yr. This is the flat rate method. An equal sum is deducted from the capital assets account covering this machine. Thus, at the end of 10 yr., we will have $900 in cash and $100 in scrap value for the machine. The schedule rate takes off a definite percentage each year. For example, we will assume that the stoker mentioned above depreciates at the rate of 10 per cent per year, and its original value was $1000. The value of the stoker at the end of each successive year is indicated in the table below.

1st year	$900.00
2nd year	810.00
3rd year	729.00
4th year	566.10
5th year	509.49
6th year	458.55
7th year	412.70
8th year	371.43
9th year	333.29
10th year	299.97

Calculation of Chimney Sizes

METHOD OF SOLUTION SHOWN BY FOLLOWING THROUGH A TYPICAL PROBLEM*

CHIMNEY design often presents a problem, the calculations of which are laborious. The net result has been that many chimneys have been constructed upon rule of thumb and guesswork methods. A chimney which is too small for the work expected of it will limit the productiveness of the plant which it serves, on the other hand a chimney which is too large is an economic waste due to excessive first cost.

Chimneys proportioned on a gas basis, as in the problem to follow, have the advantage of being definite in size and free from conjecture, whereas all proportioning by empirical formulas and tables based on boiler horsepower or weight of fuel burned are necessarily loose and often seriously misleading.

Assume for this problem that it is required to design a chimney which will serve three 300-hp. boilers which will operate at rating. These boilers will be hand fired with eastern mine-run bituminous coal which contains 15,600 B.t.u. per pound of combustible. It may be further assumed that the gas temperature at the damper will be 470 deg. F. and that the boiler manufacturer has stated that the draft loss through the boiler will be 0.20 in. of water. The grate area may be taken as 65 sq. ft. per boiler.

Allowing an efficiency of boiler and furnace of 65 per cent, there will be $15,600 \times 0.65 = 10,150$ B.t.u. used to make steam from each pound of combustible. Dividing the B.t.u. equivalent of one boiler horsepower (33,479) by 10,150, it is found that 3.3 lb. of combustible are burned per horsepower-hour, then to generate 300 hp. the combustible burned will be $3.3 \times 300 = 990$ lb. If the coal is 90 per cent combustible, the quantity burned per hour per boiler will be 990 divided by 0.90, or 1100 lb., which in turn when divided by the grate area of 65 sq. ft. will give a combustion rate of 17 lb. of coal per square foot per hour.

Draft necessary to operate the boiler and furnace will be made up of, (1) draft loss through the damper, (2) vacuum over the fuel and, (3) draft loss through the flues.

Draft loss through the damper may be neglected because it is assumed that the damper is wide open and that no draft loss is caused by it. Figure 1 shows the vacuum required in the furnace chamber for burning various fuels, the values are averages and reasonable for clean fires when hand firing and for stoker firing for average conditions. Referring to Fig. 1 it will be noted that a pressure difference or vacuum of 0.18 in. will be required to burn the coal at the calculated rate.

As previously stated the draft loss through the boiler is 0.20 in. The draft loss through flues is commonly taken as 0.10 in. for each 100 ft. of length and 0.05 in. for each right angle turn when their area is made 20 per cent larger than that of the chimney.

Assuming that the flue in this problem is 48 ft. long, and has one bend, the draft loss will be 0.10 in. The total draft loss can now be tabulated as follows:

*Curves and data used in the preparation of this article taken from a paper presented by Alfred Cotton at the 1923 spring meeting of the A. S. M. E.

Vacuum over fire	0.18
Draft loss through boiler	0.20
Draft loss through flues	0.10
Total	0.48 in

By referring to Fig. 2, the diameter of the chimney is found to be 5.85 ft. The pressure difference required to accelerate the gases in the stack may be stated as a draft loss. From Fig. 3 this will be found to be 0.47 in. for maximum capacity at the diameter previously found and at an assumed mean gas temperature in the chimney of 400 deg. F. Basing the problem upon 30 per cent of maximum capacity we find from Fig. 4 that the draft loss due to acceleration of gases is approximately 0.10 of that at maximum capacity, therefore 0.47 in. divided by 0.10 equals 0.05 in. From Fig. 5 it will be seen that the available draft at 0.3 of maximum capacity is approximately 0.90 of the static draft, therefore the required draft of 0.48 in. must be divided by 0.90, which gives 0.53 in. to which must be added 0.05 in. for gas acceleration, which makes a total static draft of 0.58 in. Referring to Fig. 6 a length of 110 ft. is found for 400 deg. F.

Confirmation should always be made of the assumed mean temperature of the gases in the chimney. In this case the entering temperature is 470 deg., from which should be deducted 60 deg. as the atmospheric temperature, which leaves a temperature difference of 410 deg. From Fig. 7 a factor of 0.85 is read for a chimney 100 ft. by 6 ft. Multiplying 410 by 0.85 and adding back the 60 deg. gives 408 deg. F. as the mean temperature in the chimney. For approximate work no further correction is necessary for this small change in temperature.

Effect of Altitude

What height and diameter of chimney will be required if the plant is located at an altitude of 3500 ft.? Referring to Fig. 8 a factor of 1.31 is read for this altitude. Therefore the necessary height will be 110 multiplied by 1.31 or 144 ft. From Fig. 9 a factor of maximum capacity of 0.867 is read. The 900 hp. to be developed is divided by this, giving 1040 hp. as the equivalent working capacity at sea level. From Fig. 2 a diameter of 6.15 ft. is found.

Effect of Winter Temperatures

What effect will a winter atmospheric temperature of 20 deg. F. and a summer temperature of 90 deg. F. have on the capacity of the plant? Reference to Fig. 10 using 400 deg. F. as the mean temperature of the chimney gases gives factors of 1.22 and 0.84 respectively for static draft. From Fig. 11 factors of 1.11 and 0.94 respectively are read for maximum capacity. Since the draft required increases approximately as the square of

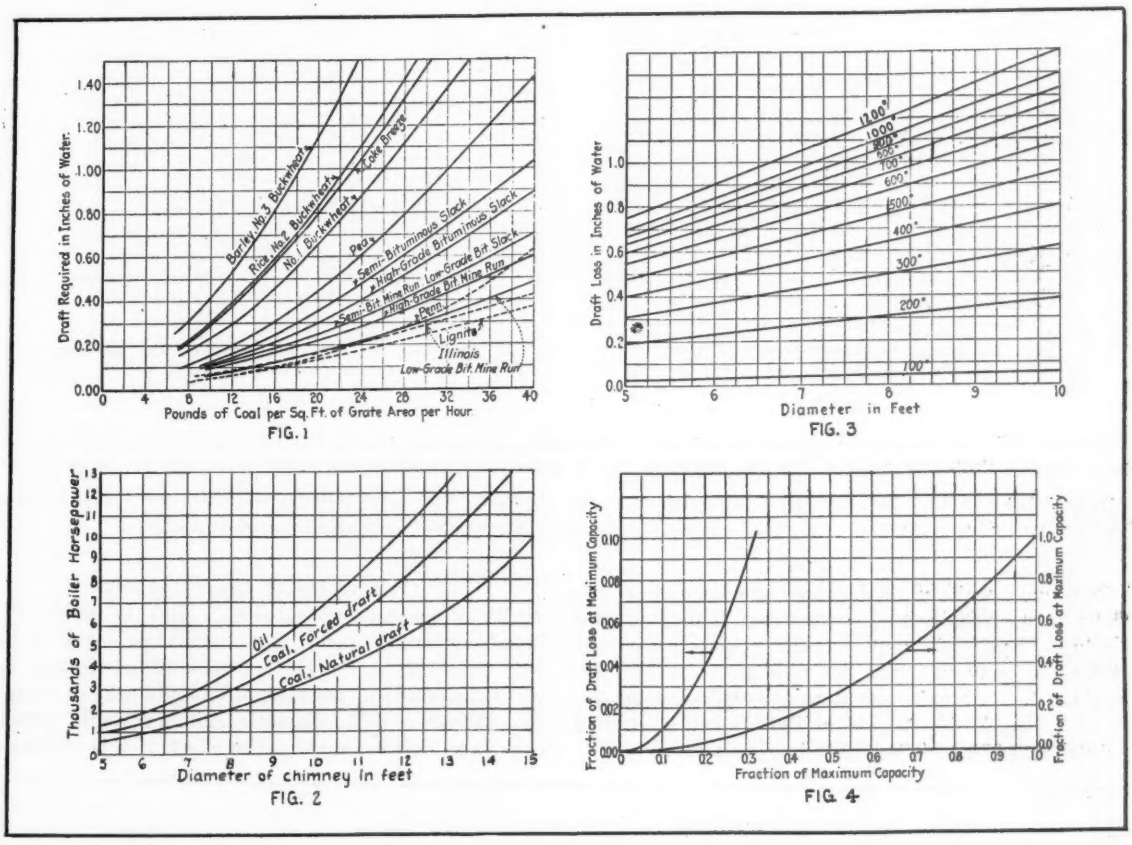


FIG. 1 FIG. 3 FIG. 2 FIG. 4

FIGS. 1 TO 4. CHIMNEY DESIGN CURVES SHOWING DRAFT LOSSES AND WORKING CAPACITIES

Fig. 1. Draft loss through fuel bed with different fuels.

Fig. 2. Working capacity of chimneys based on 60 deg. F. atmospheric temperature at sea level.

Fig. 3. Draft loss due to acceleration of gases at maximum capacity at sea level.

Fig. 4. Relation of draft-loss fraction due to acceleration of gases to capacity fraction.

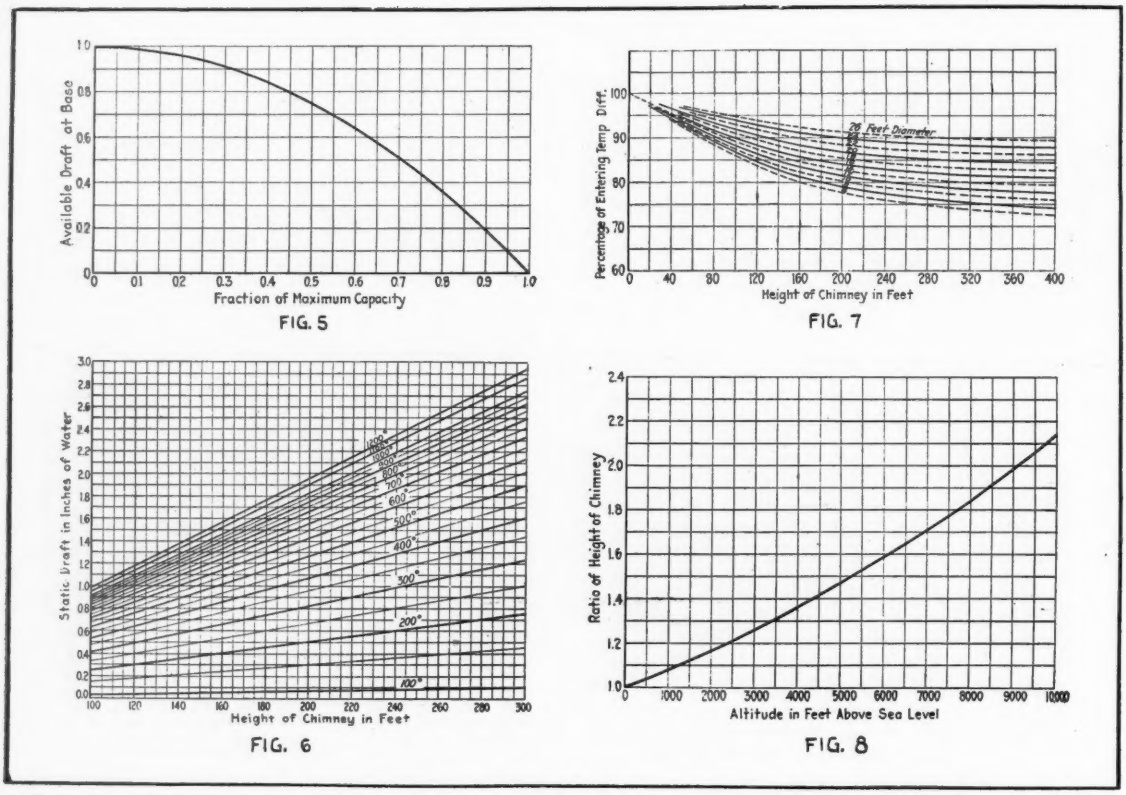

Available Draft at Base
Fraction of Maximum Capacity
Percentage of Entering Temp Diff.
28 Feet Diameter
Height of Chimney in Feet
Static Draft in Inches of Water
Height of Chimney in Feet
Ratio of Height of Chimney
Altitude in Feet Above Sea Level

FIG. 5 FIG. 7

FIG. 6 FIG. 8

FIGS. 5 TO 8. CHIMNEY DESIGN CURVES SHOWING DRAFT RELATIONS, GAS TEMPERATURES AND EFFECT OF ALTITUDE

Fig. 5. Relation of draft fraction to capacity fraction (available draft ratio).

Fig. 6. Static draft of chimneys at sea level with atmosphere at 60 deg. F.

Fig. 7. Factors for finding mean temperature of chimney gases.

Fig. 8. Effect of altitude on height of chimneys.

the load, and as the draft factors from Fig. 10 are the squares of the capacity factors from Fig. 11 the increased or reduced draft will approximately take care of the increased or reduced capacities as read from Fig. 11. Therefore the answer is that at an atmospheric temperature of 60 deg. F. 900 × 1.11 or 100 hp. can be carried in winter and 900 × 0.94 or 846 hp. in summer.

Forced Draft Installations

What increase of capacity could be obtained by installing forced draft? The dimensions of the chimney were found to be 110 ft. by 5.85 ft. diameter and these will be retained in the example for the sake of comparison, though a 6 ft. diameter chimney would probably have been decided upon. The effect of this change can

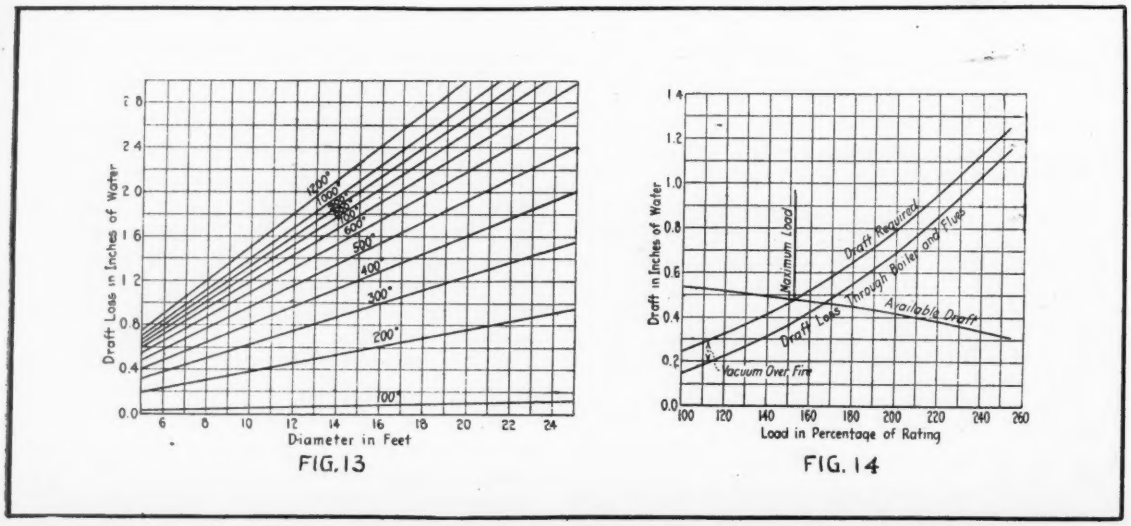


FIG. 13 FIG. 14

FIGS. 13 AND 14. CHIMNEY DESIGN CURVES SHOWING DRAFT LOSS AND MAXIMUM WORKING CAPACITY

Fig. 13. Draft loss due to gas acceleration at maximum capacity of chimneys at sea level.

Fig. 14. Example of determination of maximum working capacity of a chimney.

be shown graphically very clearly, but the calculations will first be presented as in the table given herewith to indicate the method of procedure.

Draft loss through the boiler and flues at 100 per cent of rating is 0.2 plus 0.1 or 0.3. This was for 9 per cent CO_2 which was assumed to be the condition for hand firing. From Fig. 12 it is seen that the draft loss at 9 per cent CO_2 is 2.1 times what it is at 13 per cent. Therefore the draft loss at rating will be 0.3 divided by 2.1 or, say, 0.15 at rating with the forced draft. The increase of draft loss is taken as the 2.2 power of the load, and entered in column 2 of the table. To this is added 0.1 in. as the constant vacuum over the fire at all loads, and the results entered in column 3. The horsepower developed at the different loadings is now entered in column 4.

This chimney has a working capacity with forced draft of 1370 hp. as read from Fig. 2. This is probably but not necessarily what we shall find from this closer examination because we are limited as to draft by the existing height. As previously stated the working capacity is 0.3 of the maximum capacity and the maximum capacity will therefore be 1370 divided by 0.3 or 4567 hp. with forced draft. The working loads of column 4 are divided by 4567 and the loads expressed as fractions of the maximum capacity are entered in column 5. The fraction of static draft at these loads is read from Fig. 5 and entered in column 6. The chimney static draft of 0.58 in. is multiplied by the fractions in column 6 and entered in column 7. The fraction of gas acceleration loss is now read from Fig. 4 in accordance with column 5 and entered in column 8.

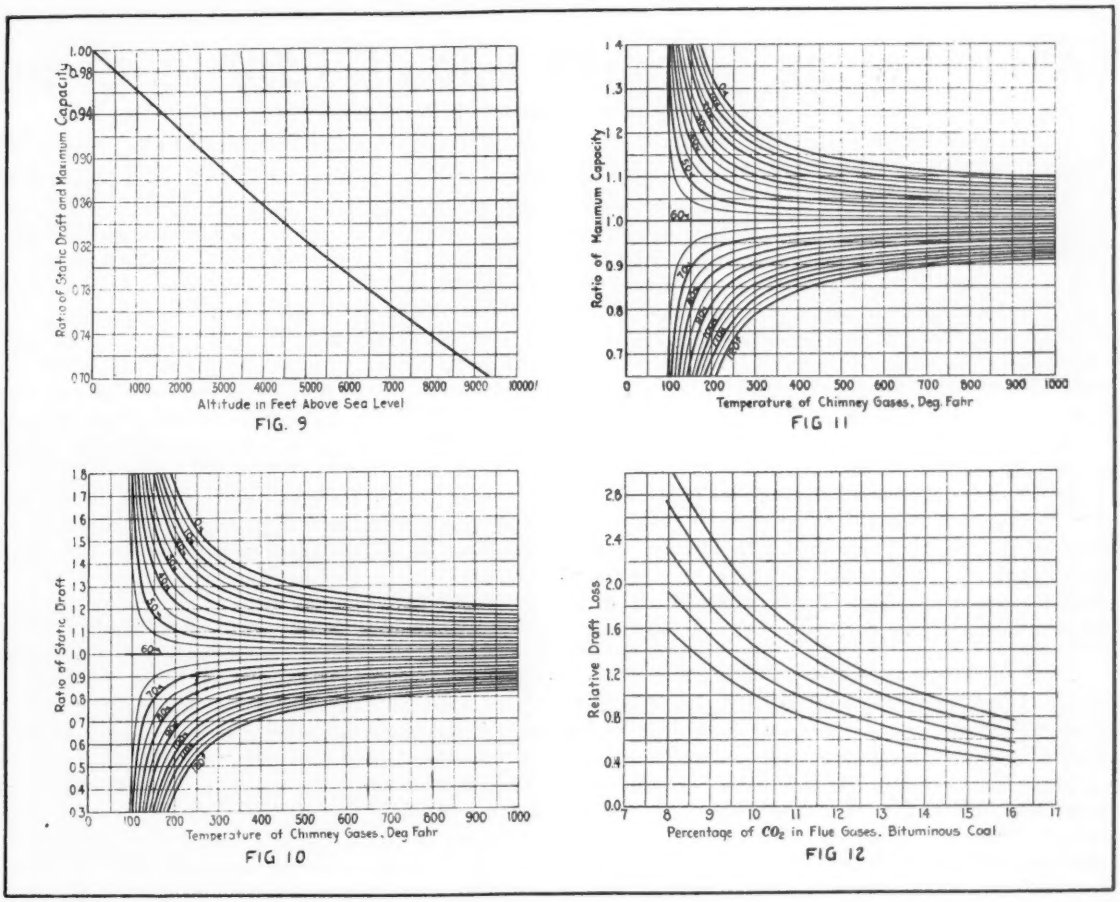

Ratio of Static Draft and Maximum Capacity
Altitude in Feet Above Sea Level
Ratio of Maximum Capacity
Temperature of Chimney Gases, Deg. Fahr
Ratio of Static Draft
Temperature of Chimney Gases, Deg Fahr
Relative Draft Loss
Percentage of CO_2 in Flue Gases, Bituminous Coal

FIG. 9 FIG. 11 FIG. 10 FIG. 12

FIGS. 9 TO 12. CHIMNEY DESIGN CURVES SHOWING RELATIONS OF STATIC DRAFT, RELATIVE DRAFT AND CAPACITY

Fig. 9. Effect of altitude on static draft and maximum capacity of chimneys.

Fig. 10. Relation of static draft with atmospheric temperatures from 0 to 120 deg. F. to that at 60 deg. F.

Fig. 11. Relation of maximum capacity with atmospheric temperatures from 0 to 120 deg. F. to that at 60 deg. F.

Fig. 12. Relative draft loss through boilers burning bituminous coal with varying proportions of excess air as indicated by CO_2 in flue gases.

The gas acceleration loss at maximum capacity is read from Fig. 13 as 0.45 in. and the total losses at the various loads as found by multiplying this figure by the fractions

TABULATION FOR MAXIMUM CAPACITY DETERMINATION

(1) Load in per cent of rating	(2) Draft loss, boilers and flues	(3) Draft loss plus 0.1 in. over fire	(4) Hp. developed	(5) Working capacity equals fraction of maximum capacity	(6) Fraction of static draft	(7) Static draft times column (6)	(8) Fraction of gas acceleration loss	(9) Actual gas acceleration loss	(10) Available draft
100	0.150	0.250	900	0.197	0.960	0.557	0.038	0.017	0.540
125	0.245	0.345	1125	0.246	0.940	0.545	0.060	0.027	0.518
150	0.366	0.466	1350	0.296	0.912	0.529	0.085	0.038	0.491
175	0.514	0.614	1575	0.345	0.880	0.510	0.120	0.054	0.456
200	0.689	0.789	1800	0.394	0.845	0.490	0.155	0.070	0.420
225	0.893	0.993	2025	0.443	0.802	0.465	0.196	0.088	0.377
250	1.126	1.226	2250	0.493	0.775	0.438	0.224	0.110	0.328

in column 8 and are entered in column 9. Deducting these from column 7 gives the available draft at the base of the chimney, which is entered in column 10.

In Fig. 14 are plotted the values of columns 2, 3 and 10. The point where the "draft required" curve crosses the "available draft" curve is the maximum working load and occurs at 153 per cent of rating or 1380 hp. At the point where the "draft loss through boilers and flues" curve intersects the "available draft" curve at 167 per cent of rating or 1500 hp. the vacuum over the fire has disappeared and flame begins to blow out of the fire doors.

flue gases. With careful operation the CO_2 may be increased and this will allow of a higher load being carried because of the smaller weight of the gases due to to the decreased excess air. To increase the possible load considerably, the height of the chimney must be increased or induced draft installed.

Possible Saving Through Use of 1200 lb. Steam*

CALCULATIONS MADE IN DESIGN OF THE WEYMOUTH STATION SHOW GAIN OF 10 PER CENT POSSIBLE UNDER IDEAL CONDITIONS.

BY I. E. MOULTROP† AND JOSEPH POPE‡

FOR the new power station of The Edison Electric Illuminating Co. of Boston, now under construction on the Weymouth Fore River, the initial installation will include two 32,000-kw. generating units with three 1974-hp. boilers, operating at 375 lb. steam pressure and 700 deg. F. In addition, a single boiler to carry steam at pressures up to 1200 lb. is to be installed. This boiler will have about the same heating surface as the normal pressure boilers. The steam generated by it will pass through a pressure reducing turbine developing about 2000 kw., and will be exhausted at 375 lb. pressure. After being reheated to the original temperature of 700 deg., the steam will be piped to the main header and used in the large turbines. If satisfactory results are obtained from the high pressure boiler-turbine units more of them will be installed. Three high-pressure turbines will be required to furnish sufficient steam to operate one of the 32,000-kw. units.

A KILOWATT-HOUR FOR 13,600 B.T.U.

No prediction is made of the expected operating performance of the station, but it is calculated that under ideal conditions, acting solely as a 375 lb. single expansion nonreheating plant, it could produce a net kilowatt-hour for 15,100 B.t.u. in the fuel and as a 1200-lb. compound reheating plant, it could produce a net kilowatt-hour for 13,600 B.t.u. These figures show the advance in heat economy that modern development in steam engineering have made possible and the advantage which the very high pressure reheat cycle possesses over the more conventional design. The actual plant performance will depend among other things upon the character of the load which it is found possible to put on Weymouth Station and the relative proportion of high and normal pressure equipment that may be operated.

Since the operating steam pressure and temperature have such an important bearing upon the possible maximum fuel economy of a station, extended study of these features was made before reaching a decision in regard to them. When suitable economizers are employed the influence of steam pressure and temperature upon the efficiency of steam generation is negligible, but the influence of these factors upon the efficiency with which the heat in the steam can be utilized is in any case of definite importance.

Temperature at which the steam should be supplied to the turbine is almost entirely a problem of materials, as the beneficial effect of superheat, although largely indirect, continues in worth-while proportion up to the maximum temperature which our engineering materials will properly withstand. In some isolated instances, European engineers have employed temperatures as high as 750 to 800 deg. F., and in America temperatures as high as 725 deg. F. have been chosen by some designers. In considering this matter for the Weymouth Station, it seemed best to place the nominal limit at 700 deg. F. It furthermore appeared entirely practicable to employ this limiting temperature regardless of the pressure adopted.

HOW THE STEAM PRESSURE WAS CHOSEN

Decision as to the most advantageous steam pressure could not be reached without a much more involved study, especially in view of the general lack of experience with the higher pressures and a decided variation in prophecy as to the net advantage to be derived through their use. The art of utilizing the higher pressures is still in a very early stage of its development.

It was apparent that this study, to be complete, would have to cover the following considerations:

1. Improvement in economy of heat utilization made theoretically possible by increased steam pressure.
2. Extent to which available equipment could be expected to take advantage of the theoretical possibilities.
3. Probable effect of increased pressure upon reliability of operation and its flexibility in meeting anticipated load conditions with high overall economy.
4. Freedom in taking advantage of future changes in the art.
5. Economic balance of carrying charges and operating costs over a long period.

One part of the study to determine the effect of the higher pressures upon improved economy is illustrated by the curves in Fig. 1. All of these curves have absolute steam pressure as their abscissae.

Curve No. 1 shows the total heat in one pound of steam at a uniform temperature of 700 deg. F., above 79 deg. F., which is the temperature corresponding to one inch absolute pressure. It will be noted that the total heat shows a decrease with increasing pressure.

Curve No. 2 shows the heat remaining in the steam after perfect adiabatic expansion from the stated initial

* The general subject matter in this article, together with further details on the Weymouth station, was presented in a paper, "Some Engineering Features of the Weymouth Station," delivered by the authors before the American Institute of Electrical Engineers at Swampscott, Mass., on June 27.

† Assistant superintendent Construction Bureau, Edison Electric Illuminating Co. of Boston.

‡ Betterment engineer, Stone & Webster, Inc.

conditions to a pressure of 1 in. absolute. The vertical distance between this curve and curve No. 1 accordingly represents the B.t.u. per pound of steam theoretically available for doing work.

Curve No. 3 is a plotting of the available heat as a percentage of the total initial heat shown by curve No. 1, and represents the efficiency of the Rankine cycle at varying pressure. Its upwardly convex curvature indicates how the rate of increase in theoretical efficiency diminishes with increasing pressure.

Curve No. 4 shows the best efficiency at present to be expected of turbo generators in converting the available heat, as shown by Curve No. 3, into useful electrical energy. In determining this curve, the unit is credited with all heat recovered in the condensate by bleeding at two stages.

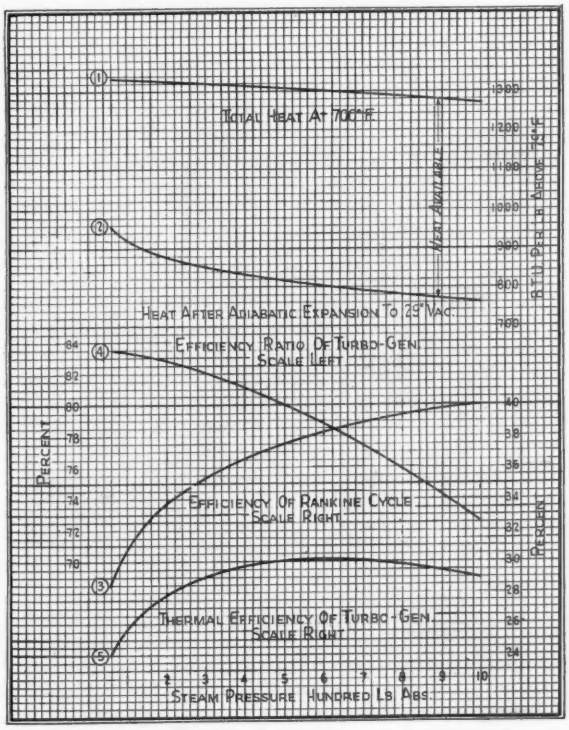

Total Heat At 700°F
Heat After Adiabatic Expansion To 29" Vac.
Efficiency Ratio Of Turbo-Gen. Scale Left
Efficiency Of Rankine Cycle Scale Right
Thermal Efficiency Of Turbo-Gen. Scale Right
Heat Available
B.T.U. Per Lb. Above 32°F
Percent
Steam Pressure Hundred Lb Abs.

FIG. 1. THESE CURVES SHOW THE EFFECT OF STEAM PRESSURE ON TURBINE THERMAL EFFICIENCY

Curve No. 5 is the product of Curves No. 3 and No. 4 and indicates, for the different pressures, the percentage of the total initial heat in the steam which would be actually converted into electrical energy or returned to the boiler in the condensate. It will be noted that this curve takes the shape of a dome with its highest point corresponding to a steam pressure of about 600 lb. absolute.

If steam turbines could be constructed which would be equally efficient in transforming the available heat energy into useful work under all of initial steam pressure conditions, Curve No. 3 would indicate that the over-all thermal efficiency would increase with the pressure throughout the entire range considered. The most important factors which act to decrease the turbine efficiency at higher steam pressure are the increased gland and interstage leakage losses and, more particularly, the increased steam friction occasioned by the entrained water after the dew point has been reached. This lowered efficiency is particularly marked where the maximum permissible total temperature causes the higher pressures to be accompanied by diminished superheat, thus advancing the dew point to an earlier stage. The recognized method of meeting this difficulty, and thus permitting the superior possibilities of higher steam pressures to be realized, is to interrupt the expansion of the steam at some intermediate pressure and restore its temperature by reheating before the expansion is continued. This may be accomplished either by employing two independent turbines, one exhausting to the other through the reheater, or by returning the reheated steam to the lower stages of the same machine from which it was extracted. The design of the Weymouth Station makes provision for employing the first of these two methods using a maximum pressure of 1200 lb.

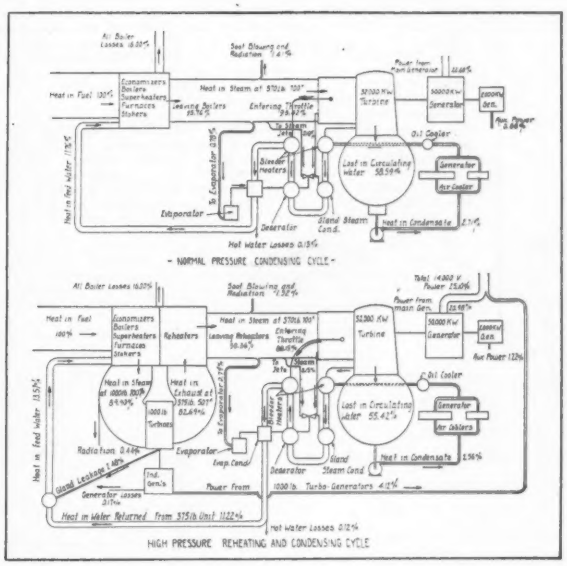


FIG. 2. COMPARISON OF THE NORMAL PRESSURE CYCLE WITH THE HIGH-PRESSURE REHEATING CYCLE

Exhaust from High Pressure Turbine is Dry

In order that the reheater may be required to add superheat only to the steam, it is necessary that the exhaust from the high pressure turbine be dry. The amount of energy that may be extracted from a given weight of steam between an initial condition of about 1000 lb. at 700 deg. and the dry saturated condition is only a fraction of that which can be utilized by its further expansion to vacuum after reheating. This condition permits the use of large standard design turbine units for the second expansion stage of the cycle. Thermodynamically it makes little difference in the cycle efficiency at what pressure the steam is reheated, or, indeed, if it is reheated at all. In practical opera-

tion, there is a certain pressure at reheat which gives the best combined efficiency of the two turbines working in series, but the efficiency at this pressure does not appear to be a great deal higher than at other pressures rather widely different from it. Of greater importance are the mechanical problems connected with rehandling the steam and the higher the pressure, within limits, the easier these become. For the particular situation under discussion, it was desirable to have the lower pressure portion of the plant able to function as a complete and highly economical station, so that the same considerations which control the selection of an initial pressure for the single expansion cycle were allowed to govern the choice of a reheat pressure in this case. Although it appears from Curve 5 of Fig. 1 that about 600 lb. is the most efficient pressure for a single expansion unit, cost influences make a somewhat lower pressure more economical to use. For Weymouth Station the pressure selected is 375 lb.

Normally the high pressure boilers will deliver steam at approximately 1000 lb. pressure and 700 deg. F. total temperature, corresponding to about 153 deg. of superheat. The entire steam output of each boiler, which under the usual operating conditions will be about 110,000 lb. per hr., will pass through a simple three stage turbo generator where it will be expanded down to a pressure of 375 lb. The steam will then be reheated to 700 deg. in a reheater installed in the same boiler setting, and finally be discharged into the 350 lb. header serving the main turbines. It may be noted from the quantity of steam passing through each of the high pressure turbines that three such boiler-turbine units will be required to supply one of the main 32,000-kw. turbines at the higher loads. Operating under the conditions outlined each of the high pressure turbines will generate about 2000 kw. Thus a total of 6000 kw. will be generated in reducing the pressure of the steam required by one of the main units.

In the Weymouth Station the turbine room is to be located adjacent to the water front so that the condensing water tunnels will be direct and short. These tunnels are designed to give the same ease of flow as though they were to serve hydraulic turbines. The boiler room adjoins the turbine room on the land side and lies between the latter and the isolated building for the buses and electrical control.

Initial main generating equipment will consist of two 32,000 kw. turbines each driving a main 30,000 kw. generator and a 2,000 kw. auxiliary generator direct connected to the shaft of the main generator. These units will be supplied with steam at a nominal pressure of 375 lb. and a total temperature of 700 deg. F. There will also be one 2,500 kw. high back pressure turbo generator taking steam up to 1,200 lb. pressure and exhausting into the 375 lb. system. All station auxiliaries are to be driven by alternating current motors.

Boiler installation will include three boilers each containing 19,743 sq. ft. of heating surface, with additional superheater and economizer surface, designed for 375 lb. working pressure. There will also be one boiler, of approximately the same heating surface, which will be designed to operate at a maximum of 1,200 lb. It will likewise be provided with a superheater and an economizer, and also a steam reheater to restore the temperature of the exhaust steam from the high back pressure turbine to 700 deg. before it passes into the 375 lb. system. All boilers will be fired with underfeed stokers.

The coal handling equipment will consist of two electric unloading towers, a traveling bridge spanning the storage pile, and a system of belt conveyors for transporting the coal to or from the main storage or directly from the unloading towers to the station bunkers.

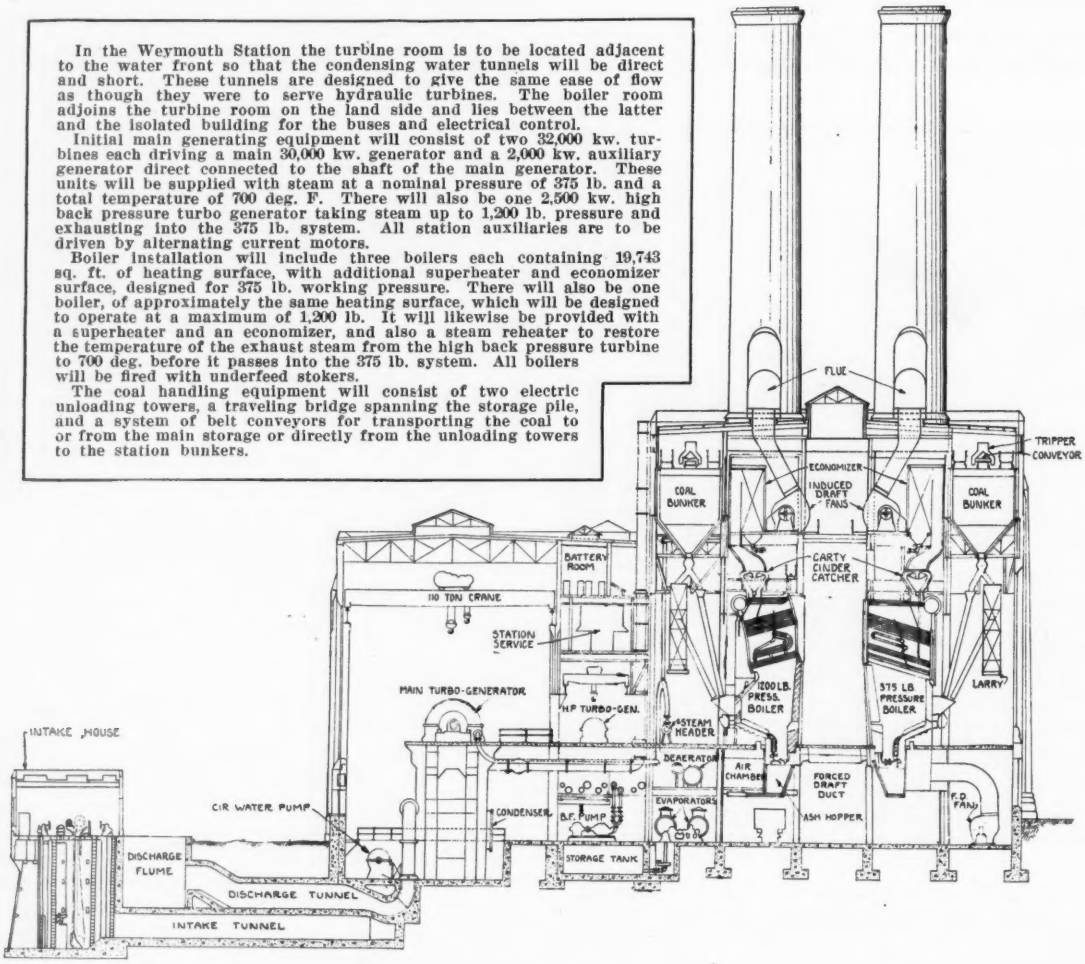


FIG. 3. WEYMOUTH STATION WILL HAVE 1200 LB. AND 375-LB. BOILERS AND THE HIGH-PRESSURE TURBINES WILL BE IN A SEPARATE ROOM FROM THOSE OPERATING AT 375 LB.

Feed Water Heating by Bleeder Steam and Economizer

Feed water heating is to be accomplished both by steam extraction from the main turbines and by the use of economizers. To obtain the maximum of benefit from the steam extraction method of heating motor driven auxiliaries only are to be used, supplied with

power from a most efficient direct connected auxiliary alternator. The auxiliary apparatus itself has been selected with a view to obtain the highest efficiency in both the driving and driven members.

Figure 2 shows, in the upper diagram, an analysis of the performance which could theoretically be realized in the operation of the normal pressure (375 lb.) portion of the station of the design as described. The lower diagram shows a similar analysis for such a station operating exclusively on the reheat cycle, with the entire steam supply generated at 1000 lb. Both diagrams are based upon ideal operating conditions—i.e., a constant station load of such amount and character as would permit the main units to operate at their point of best efficiency and at 100 per cent load factor. The estimated efficiency of each individual piece of equipment is that guaranteed by the manufacturer.

From these diagrams it will be observed that the normal pressure straight condensing plant will transform 22.6 per cent of the heat in fuel into electric energy, which is equivalent to 15,100 B.t.u. per kw.-hr. net generated, or approximately 1.05 lb. of coal of a heat value of 14,400 B.t.u. per lb.—while the corresponding figures for the high pressure reheat plant are 25.1 per cent, 13,600 B.t.u. per kw.-hr. and approximately 0.945 lb. of coal.

These calculated results represent only the ultimate possibilities under ideal load conditions. It is, of course, impossible to predict what the results of actual operaton will be, as this will be influenced considerably by the extent to which a constant base load can be allocated to the Weymouth Station and the extent to which it is found advisable to employ the high pressure equipment in making future extensions to the station.

Steam Cylinder Lubrication*---II

An Outline of Operating Conditions as Influenced by Various Steam Conditions

LET US CONSIDER what conditions a cylinder oil has to meet and how they can be met satisfactorily. The principal conditions affecting a cylinder oil are the pressure, temperature, percentage of moisture and the degree of superheat of the steam. There must also be considered priming and foaming of the boiler and the use to which the condensed steam is to be put after it has passed through the engine.

Steam pressure as a pressure has practically no effect on the oil, but the temperature necessary to obtain the pressure and the degree of superheat have a very marked effect. The evaporation of the oil film from the cylinder, and especially the valve surfaces, will be more pronounced with high temperatures of steam than with low temperatures of steam, thus requiring either a heavier bodied oil or a larger quantity of a lighter bodied oil to obtain satisfactory lubrication. The atomization of the oil is a function of the temperature as well as of the velocity of the steam. With high temperatures a heavy bodied oil, due to the thinning effect of the heat, can be more easily atomized than it can at a low temperature. This is a decided advantage, as heavier bodied oils adhere to the cylinder walls better than do lighter bodied oils, hence are more economical.

There is a limit, however to the length of time that it is advisable to have the oil remain on the cylinder walls, as under the temperature condition of high superheat the oil may carbonize and cause gumming and sticking of the moving parts. This is especially true in the valve chambers, where the temperature is constantly higher than that in the cylinder. The low temperatures usually accompanying low pressures will not satisfactorily atomize heavy oils, except under very high velocities, and so under these conditions it is necessary to use an oil of low viscosity. This, however, is not as great a drawback as it may seem at first glance, as under these low temperature conditions properly refined oils do not evaporate from the lubricated surfaces too rapidly for good practice.

One of the most important factors determining the characteristic requisite for a cylinder oil is the saturation of the steam. Unless highly superheated, steam contains moisture by the time it reaches the cylinder, and even if it is not wet when it enters the cylinder some water will be produced by the cooling effect of the cylinder walls and by the heat expended in the expansion stroke. Moisture in steam will wash a pure mineral oil from the cylinder walls quite rapidly, and in order to get satisfactory lubrication under wet steam conditions large quantities of this type of oil will be necessary. This will mean that more oil will be fed into the system than can be satisfactorily atomized and carried through it, and will result in a collection of oil in the cylinder, which is an ideal condition for the production of carbon. This is especially true if the engine is of multiple expansion type and there are receivers and re-heaters between the cylinder, especially the latter.

If oil is separated in re-heaters, it is generally subjected to unusually high temperature conditions and even the best oil may carbonize and cause trouble on account of the carbon being carried over into the low-pressure cylinders. This carbonizing effect on oil by high temperatures is especially apt to happen in the case of poppet valve spindles, and on account of their small clearances they may become so gummed that the steam action of the engine may be impeded and a loss of power brought about.

Compounding

It has been found, however, that if mineral oils are combined with small amounts of some fatty oils, as tallow or degras, a cylinder oil is produced which resists the washing action of wet steam. This compounded oil forms an emulsion with the moisture on the wet surfaces and clings so tenaciously to them that it is not washed away rapidly by the excess of water in wet steam. A large quantity of water may so dilute this emulsion that it will wash away, but an oil film will be quickly re-formed on the walls as soon as steam conditions become normal again. If, however, instead of a compounded oil a pure mineral oil is used, the moisture remaining on the cylinder walls after a dash of wet

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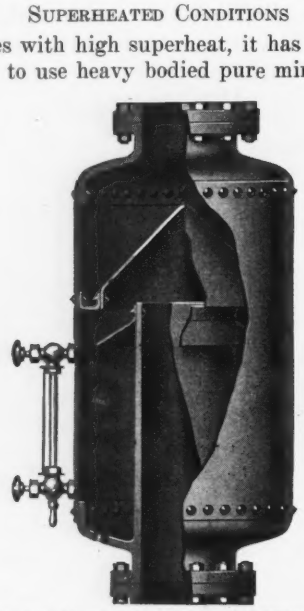
steam has passed through, is not easily displaced by the oil, and lubrication is either destroyed or at least becomes unsatisfactory. The amount of compounding required in the cylinder oil is largely dependent upon the percentage of water or moisture in the steam.

An excessive amount of fatty oil beyond that necessary to form an emulsion does not improve the lubricating value of the oil and may even be a detriment, as fatty oils generally decompose under high heat conditions and may give trouble on that account. It is also difficult to maintain large amounts of fatty oils successfully in solution with mineral oils without separation or segregation. Improved refining methods have reduced the amount of compounding necessary to secure good lubrication, and now cylinder oils contain much less fatty oils than in former years.

Superheated Conditions

In engines with high superheat, it has been the general practice to use heavy bodied pure mineral oils, and



EFFECT OF PRIMING MAY BE PARTLY ELIMINATED BY USE OF A STEAM SEPARATOR

as a result good lubrication has not always been obtained, and it has been the general opinion that such machines are very hard to lubricate. This use of a pure mineral oil is no doubt due to the fact that cylinder oils were too often used which were not properly refined or compounded with such fatty oils as would withstand the carbonizing effect at the high temperature of superheated steam.

Unless very high superheat is used, steam at the exhaust will show some moisture, and as we must lubricate the cylinder on the exhaust stroke as well as on the expansion stroke, we must use a slightly compounded oil that will take care of slightly wet conditions. Even if the exhaust from the high-pressure cylinder remains dry, that of the low-pressure will be wet. This, of course, can be taken care of by using a different oil on the high and low-pressure cylinders, but this is not necessary as oils are now made which will take care of both conditions satisfactorily.

Another difficult condition which a cylinder oil must meet is the priming of the boiler and the carrying over of the boiler compound into the cylinder. Whether this may become serious or not depends on the character of the boiler water and the means used to soften it. Some plants soften the water before it is pumped into the boiler, in which case if the action is completed the only effect of priming on the cylinder is the production of wet steam; but such cases are not frequent, as unless there is some compound in the water, boilers do not usually prime except under very heavy loads. Most boiler compounds contain soda, which when carried over by the wet steam combines with the fatty oil constituents in the cylinder oil, destroying at least part of its emulsifying effect. In order, therefore, to maintain a lubricating film, more oil must be fed than would normally be required. There are generally other substances besides soda carried over, however, and these combine with the oil to form sludges. These sludges choke the piston rings and valves, causing leakage of steam, loss of power, and wearing of the sliding parts. Sludges are more noticeable with heavy cylinder oils than with light ones.

Bad effects of a priming boiler may be at least partly eliminated by the use of separators before the steam enters the cylinders. These differ in design but aim to throw out the water and hence most of the impurities, allowing only dry clean steam to enter the cylinder.

If wet steam from a priming boiler is passed through superheating coils the water is driven off and fine deposits of boiler impurities are formed in the coils. These deposits, consisting of iron salts and rust as well as boiler salts, are blown over by the steam into the cylinder, and not only form heavy sludges with the cylinder oil but being more or less insoluble act as abrasives, grinding the cylinders and valves. The sludges formed under these conditions by the action of the superheated steam, bake onto the exposed surfaces, and absorb more oil, thus producing ideal conditions for the carbonization of the oil absorbed. If the oil is compounded the deposits formed under these conditions, while not decreased in quantity, do not become as hard and caked as in the case where straight mineral oil is used.

Selection of Oils

We have outlined above some of the operating conditions which must be met by a satisfactory cylinder oil. It has been firmly established after many years of practical experience that in order for a steam engine to run smoothly and economically it must be lubricated with that cylinder oil which is exactly suited for its own operating conditions.

Oil must also be applied in the proper manner, at the right place, and in the right quantity. The type of engine has little bearing on the type of lubricant to use. Much more important are the temperature and pressure of the steam, its saturation, the probable degree of atomization of the oil, and the use of the exhaust steam. We shall first consider the types of cylinder oils generally manufactured, which may be used to meet the various operating conditions of the engine.

There are in general three classes of cylinder oil stocks from which the final product may be compounded:

1. Fire stocks.
2. Steam refined stocks.
3. Filtered stocks.

These naturally may be also subdivided according to the amount of treatment each has received. The fire stocks are the less refined and may vary considerably in

quality and characteristics. They are usually more heavy bodied and sticky than the others, but will probably carbonize more quickly than more refined oils. The steam refined oils are, as the name indicates, more or less treated by live steam, the amount of treatment depending on the grade. By this treatment, there are removed many of those harmful ingredients of the crude stock, which would be most likely to decompose and form harmful deposits. The filtered oils receive additional treatment to that given to the steam refined oils, by being passed through some filtering medium whereby they are brightened in color and lose most of the objectionable ingredients; but these so-called objectionable ingredients, although the source of carbonization, are of the same character as those which give that desirable adhesive quality which causes the oils to cling tenaciously to the cylinder walls. The more refined oils atomize and separate from water more readily than the fire stocks or less refined oils. It is therefore evident that refining alone does not necessarily make a cylinder oil the most suitable for the purpose, but all the operating conditions must be taken into consideration in selecting the proper oil to use.

The foregoing stocks may be used as such, as is generally the case with marine engines, but usually they are compounded with different quantities of some suitable fatty oil. As stated previously, the compounded oils are the most satisfactory to use where wet steam conditions prevail, as they are less easily washed off from the cylinder walls and valve surfaces. Different conditions may be satisfactorily met by using a combination of varying amounts of fatty oils with cylinder oils, and in many cases it is found advisable, in order to meet particular conditions, to use several fatty oils in the final products. From this it is evident that there is possible an almost endless number of compounded cylinder oils each designed to meet a particular condition. This multiplicity naturally is impractical from a manufacturing standpoint, and the skill of the refiner is shown by his ability so to refine and compound his stocks that he can satisfactorily meet the many operating conditions with the fewest number of cylinder oils.

Strength of Wire Rope Over Sheaves

WIRE ROPE in actual use is generally weakest at the points where it passes over sheaves, especially those of small diameter; but hitherto few strength tests have been made under these conditions, although many have been made on the straight rope. The Bureau of Standards has made tests under these conditions, the rope being connected between two sheaves, one on each head of the testing machine. The rope was socketed and was made continuous after placing on the sheaves by joining the sockets.

Under the load, it was found that the rope usually broke where it left the sheave. Ropes used were 5/8, 3/4, 7/8, 1 and 1¼ in. in diameter, and the sheaves were 10, 14, and 18 in. in diameter. It was found that the strength of the rope was less the smaller the sheave. Taking the strength of the straight rope as unity, the strength of the 5/8-in. rope over sheaves was 87.4 per cent for the 10-in. sheave and 95.3 per cent for the 18-in. sheave. The larger ropes had a much lower strength, as the 1¼-in. rope had a strength of only 75.8 per cent on the 10-in. sheave and 84.7 per cent on the 18-in. sheaves.

Some of the tests were made under repeated loads representing approximately the working loads, others were made under loads which were gradually increased to the ultimate. The elongation and decrease in diameter were measured and conclusions drawn about the behavior of wire ropes under service conditions.

It is probable that one heavy load squeezes more lubricant out of the core than does a lighter load repeated many times. Rapid wear of the wires may result from this loss of the grease which was provided to lubricate them.

A worn rope which was tested with the others showed surprisingly high strength considering its condition. Detailed results of these tests are embodied in Technological Paper No. 229 of the Bureau of Standards, which can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C. The price is 10 cents.

Romance of the Engine Room

NOT LONG ago, a proud old engineer dug out from among his personal belongings an old ledger, worn but still carefully preserved; he entered a few notes in it and then put it back in its resting place.

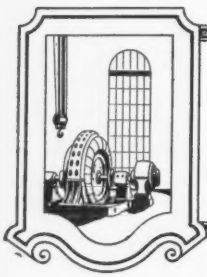
This scene had been enacted off and on for 22 yr. for it had been just that length of time since he had assumed charge of the big vertical cross compound mill drive Corliss. In that length of time many occurrences had taken place which some day might prove of interest. The old engineer saw into the future, and so he started the ledger, a story of the engine with which and for which he lived.

Finally came the day when it was necessary to rebore the cylinders and rebabbit the main bearings. The old engineer carefully watched each move of the erectors and machinists, but during odd moments he would get out the old ledger and from it he wove the story of 22 yr. of faithful and efficient service of man and machine. The story told of hours operated, loads carried, shutdowns, Sunday repairs. Many sketches and indicator cards helped to tell the story.

Not until this story was complete and had passed from hand to hand of the men higher up did they realize what the service of that man and engine had meant to them and they saw, too, written deep into that story, that the foresight which had prompted the keeping of that ledger had also developed the tie of pride which had caused the engineer to give his best to that engine in order that it might have a clean record of performance.

There is many a record, kept as was this ledger, which if gotten out and studied would reveal not only an interesting story, but it would also divulge much economic data valuable to the man who would have a full appreciation of past service and a working basis for a study of the present and the future.

AMERICAN COAL shipped to France during 1921 reached the total of 607,531 T., but for the year 1922 it dropped to the low level of 12,012 T.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Principles of Direct Current Control

FUNCTIONS, PRINCIPLES OF ACTION AND METHODS OF DETERMINING LAYOUT FOR ACCELERATING RESISTORS. BY GORDON FOX

AN ELECTRIC controller may be defined as a means for connecting and disconnecting a motor from its source of electric power and means for modifying electrical conditions to govern the performance of the motor.

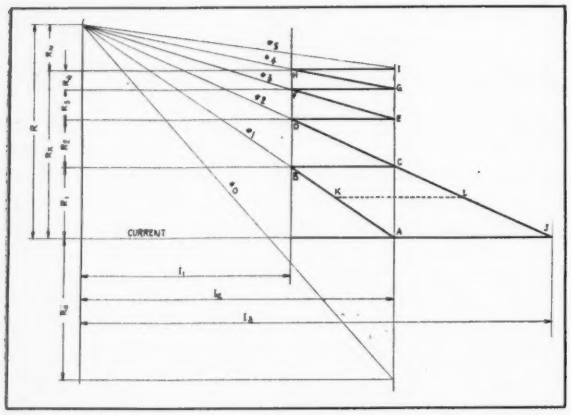


FIG. 1. RELATIONS OF CURRENT, SPEED AND RESISTANCE IN STARTING A DIRECT CURRENT SHUNT MOTOR

The primary functions of a controller may be enumerated as follows:

To start and stop the motor, usually by connecting to and disconnecting from the source of power.

To govern the acceleration of the motor and provide proper accelerating and decelerating conditions.

To control the direction of rotation.

To control the direction and amount of torque.

To control the flow of current.

To control the speed of rotation.

To protect operator, machinery, motor and controller.

To simplify and reduce the demands on the operator.

To Start and Accelerate the Motor

Motors are designed with particular reference to running conditions. Controllers are depended upon to provide proper conditions during accelerating and decelerating periods. They are somewhat analogous to the throttle valve of an engine or the clutch of a mechanical drive. The ohmic resistance of the armature of a direct current motor is low. When the motor is at rest only the resistance of the armature circuit, including the series and interpole windings and series brake coil (if used), is available to restrict the flow of current. If full voltage were applied to this circuit, with the armature at rest, an excessive current inrush would result. To restrict the initial current it is necessary to increase the resistance of the armature circuit by introducing an external resistor. This resistor is given such a value that the total resistance in the armature circuit is sufficient to restrict the current inrush to a desired amount when full voltage is applied to the circuit.

As the armature accelerates, a voltage is generated within it due to movement of its conductors through the field flux. The value of this voltage depends upon the field strength and the armature speed. The direction of this counter voltage is such as to oppose the impressed voltage. The net voltage available for driving current through the total resistance of the armature circuit (including the external resistor) is the difference between line volts and generated counter volts. As the counter voltage increases with the acceleration, the total resistance of the armature circuit may be reduced by diminishing the external resistor. As the armature approaches full speed, its counter voltage becomes only slightly less than line voltage. The external resistor may then be eliminated as the resistance of the armature and series winding is then sufficient to restrict the flow of current resulting from the net voltage or difference between line volts and counter volts.

Small direct current motors, of fractional horsepower sizes, may be accelerated from rest without the use of external resistors. This is permissible because of their small size, limited current, low inertia and quick acceleration. Series and compound wound motors are best suited to this practice as the current inrush strengthens the field and causes the counter voltage to build up rapidly.

In a few special cases, motors are accelerated from rest by building up the impressed voltage as the motor accelerates and builds up its counter-voltage. This is feasible only when the motor takes its power from an individual generator, as in some main reversing drives of steel mills and in mine hoist applications.

To Control the Direction of Rotation

Many motors operate regularly in a single direction which is determined at the time of installation and there is no need for means in the controller to bring about reversal of rotation. Some motors operate ordinarily in a single direction but are occasionally required to reverse. A printing press drive is an example of this class. Some motors, such as those driving elevators and hoists, are required to operate in either direction at will. Some mo-

tors, such as those driving laundry washers and metal planers, must reverse repeatedly according to the cycle required by the driven machine.

To reverse the direction of rotation of a direct current motor it is necessary to reverse the relative direction of flow of current in armature and fields. If the polarity of the fields be fixed, a reversal of armature current causes a reversal in direction of torque due to current in armature conductors reacting upon field flux.

In either a shunt or series motor is it possible to reverse rotation by reversing either armature or field. If the fields of a compound wound motor be reversed, both series and shunt windings must be reversed in unison. It is therefore advisable and more common to reverse the armature connections to reverse rotation. In the case of interpole motors the interpole winding must be considered as part of the armature circuit.

Reversal of armature current is ordinarily brought about by reversing armature connections at the controller. In a few special cases, current is reversed by reversing the polarity of the generator which feeds the motor armature.

To Control the Direction and Amount of Motor Torque

Direction of torque in a motor armature depends upon the relative direction of current flow in armature and fields. In the usual case, a motor revolves in the direction of its armature torque. When a motor rotates in opposition to its torque it becomes a generator. The torque may be in opposition to the rotation when a motor is "plugged," when dynamic braking is applied or when it is driven as a generator by an overhauling load.

If a motor be "plugged" by reversing armature connections quickly while running, the direction of the torque will immediately reverse but the rotation will not reverse until the reversed torque, plus the mechanical load, can overcome the inertia of the motor and driven machine, bringing the motor to rest. For a brief period the direction of motor torque is opposed to its direction of rotation.

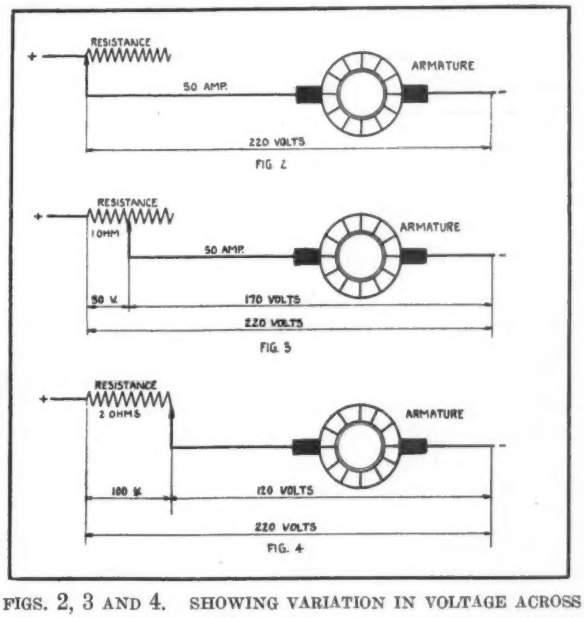
Dynamic Braking

If a rotating armature be disconnected from the line and short circuited through an external resistor, at the same time maintaining the field flux, the voltage generated in the armature by rotation past the fields, will cause current to flow through the armature and the resistor short circuiting it. This current will react with the field flux to produce a torque opposing rotation, the motor acting as a generator, the resistor being the load. This process results in a decelerating torque opposing rotation and is commonly termed "dynamic braking."
The current for exciting the field coils of the motor may be taken from an external source or may be generated by the motor itself. Shunt, compound and series motors may all be arranged for dynamic braking.

Overhauling Loads

In the case of crane hoists and other "overhauling" loads, a condition arises where the motor torque may oppose rotation. An empty crane hook must be driven downwards against the friction of the hoisting gear. In lowering a heavy load, not only is the friction of the hoisting gear overcome but the load tends to speed up the motor, increasing its counter-voltage above the impressed voltage. This causes the armature current flow to reverse, converting the motor into a generator, with torque opposing the rotation. If the motor pumps electric power back into the system, the term regenerative braking should be used. If the power generated in the motor is dissipated in resistors the term dynamic braking may be applied.

If a motor be fed from an individual generator and if the voltage of the generator be reduced below the counter-voltage developed by the motor the latter becomes a generator and the current flow is reversed so long as the condition continues. This is one case of regenerative braking. It occurs only with reversing drives such as used in steel mills and for mine hoists.



FIGS. 2, 3 AND 4. SHOWING VARIATION IN VOLTAGE ACROSS AN ARMATURE IN SERIES WITH A REGULATING RESISTOR

If an adjustable speed motor, operating at high speed with weakened field, have its field suddenly strengthened, the counter-voltage builds up and exceeds the impressed voltage and the current reverses, causing a regenerative braking influence which quickly slows down the motor. This action may be quite severe.

The amount of torque which a motor develops depends directly upon the magnetic field strength and the amount of armature current. In a shunt motor, having a nearly constant field flux, the torque developed is, within practical limits, proportional to the armature current. In a series or compound wound motor the torque increases in a somewhat faster proportion than the current. In any motor the torque can be governed by controlling either the field strength or the armature current. In the majority of cases the armature current is varied. In accelerating a motor, the armature current is limited, not only to protect the motor and the electric system but also to protect the driven machine against the sudden application of too high torques. In dynamic braking, the armature current is governed by adjustment of the resistor which short circuits the armature. This controls the braking torque. In a crane hoist drive, the restricting torque in lowering is controlled by ad-

justment of both armature current and field strength, all by means of resistors in the armature and field circuits.

Sometimes motors are called upon to stand practically at rest and merely exert torque. In such cases the amount of torque developed and current passed are controlled by resistors which are then usually termed "jam resistors." The conditions here correspond to those existing when starting a motor from rest.

To Control the Amount of Current

When a motor is in operation on full voltage, the current is determined primarily by the mechanical load demand. As already stated, when accelerating, plugging,

TABLE I. NUMBER OF RESISTOR DIVISIONS FOR STARTING DIRECT CURRENT MOTORS UNDER FULL LOAD

Manual Control		Magnetic Control		
Horse-power	All Motors	Shunt Motor	Compound Motor	Series Motor
5– 10	4	2	2	2
15– 25	4	3	2	2
30– 45	4	4	3	2
50– 75	7	4	3	3
80–125	7	5	4	3
135–275	9	6	4	4

retarding, braking, jamming and for other special purposes, resistors are used to introduce voltage drop and thus to restrict both current flow and torque production.

The determination and layout of proper accelerating resistors involves many factors.

Three primary questions are involved, namely:

Total amount of resistance.

Subdivision into steps.

Current and thermal capacity.

The total accelerating resistance required depends primarily upon two factors, namely, the allowable current inrush and where speed control by armature resistance is used, also the range of speeds desired. The current inrush permitted may be adapted to suit the starting load conditions. If a motor is to be started without load or with light load, a lesser current inrush will suffice than if heavy starting torque is demanded. The torque produced per ampere of starting current depends, to some extent, on the type and size of motor. In Table II are shown the peak torques developed by shunt, compound wound and series motors (also wound rotor induction motors) with several values of initial current inrush.

Having determined the initial current inrush to be permitted to develop the required starting torque, the total resistance to be inserted in the starting circuit may be calculated. Dividing the line voltage by the initial current inrush gives approximately the total resistance required in the armature circuit to restrict the current inrush to the selected value. The internal resistance of the motor and series brake circuits and that of the leads must be subtracted to determine the external resistance to be supplied. The resistance in the circuit also tends to decrease the current inrush to some extent. The total resistance, found by dividing the line voltage by the current inrush, may be decreased 10 to 20 per cent to allow for resistance and reactance of the motor and leads. The external resistor is thus determined.

If armature resistance speed control is desired, the speed range required may demand a higher value of armature circuit resistance than is needed to restrict the starting current and torque. The determination of resistors for speed control service is discussed in following paragraphs.

Resistance Steps for Acceleration

Reference to Fig. 1 which shows the general relation of current and speed in starting a direct current shunt motor will be of value in explaining the general principles of accelerated resistor layouts. The full load current of the motor is I_1. We will assume that current peaks of 150 per cent full load current are permissible and will determine I_2 accordingly. The total resistance of the armature circuit may be such that, in starting from rest, a current equal to I_2 flows. This amount of resistance gives armature regulation curve No. 1. As the motor accelerates, the current falls off along this curve until some point such as B is reached, where a block of resistance is cut out, again increasing the current to I_2. The motor then accelerates further until, at point

TABLE II. ELECTRIC POWER CLUB SERVICE CLASSIFICATION OF ACCELERATING RESISTORS

Percent of Full Load Current on First Point	Starting Torque in Percent of Full Load Torque				Resistor Class Number				
					Starting Duty		Speed Regulating Duty		
							Intermittent		
	Series Motor	Compound Motor, 30% Series	Shunt Motor	Wound Rotor Induction Motor	Light 15 Sec. in 4 Min.	Heavy, 30 Sec. in 4 Min.	Light 1 Min. in 4 Min.	Heavy 2 Min. in 4 Min.	Continuous
25	8	12	25	.....	11	31	51	71	91
50	30	40	50	30	12	32	52	72	92
70	50	60	70	50	13	33	53	73	93
100	100	100	100	100	14	34	54	74	94
150	170	160	150	150	15	35	55	75	95
200	250	230	200	200	16	36	56	76	96

D, further resistance may be cut out. This process is repeated until the external resistor is entirely cut out of the armature circuit and only the resistance of the motor and leads remains. The motor regulation curve No. 5 then results.

If the motor does not start on the first point, a current I_3 equal to approximately 200 per cent of full load value will be taken when the first step of the resistor is short circuited, as shown by point J. The dotted line KL shows that if the motor starts on the first point, but the first step is cut out before point B is reached, a higher current than I_2 will result.

This speed-current chart may be used to indicate how the resistor should be subdivided. Let R be the total calculated resistance and R_m be the allowance for resistance of motor and leads. R_x is then the external resistance required. This will be subdivided into steps R_1-R_2-R_3-R_4 as shown.

It should be noted that the current intake decreases as the motor accelerates on any resistance step. The torque developed falls off roughly in like proportion. The minimum or valley current must be maintained more than sufficient to meet load torque requirements in order that acceleration may continue. The rate of acceleration will depend upon the difference between the torque developed by the motor, due to the current admitted, and

TABLE III. PROPORTIONS OF ACCELERATING AND SPEED REGULATING RESISTORS FOR USE WITH MANUAL STARTERS AND SPEED REGULATORS

No. of Steps	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11
Character of Load Constant Torque or Varying with Speed		Constant	Varying	Constant	Varying	Constant	Varying	Constant	Varying	Constant	Varying	Constant	Varying	Constant	Varying
Step															
1	37	30	37	25.3	33.3	21.7	29	19.3	26.0	17.0	24	15.0	22	13.7	20.0
2	28	24	26	21.0	22.2	19.0	21	16.7	19.5	15.3	17.8	13.7	16.4	12.8	14.6
3	20	19	16	17.5	16.0	16.3	15	14.7	14.5	13.5	13.7	12.5	13.3	11.7	13.6
4	15	15	12	14.5	11.8	13.5	12	12.8	11.5	11.7	11.2	11.3	10.7	10.8	10.6
5	.....	12	9	11.7	9.3	11.3	9	11.0	9.0	10.5	9.0	10.2	9.1	9.7	8.7
6	.....	.....	.....	10.0	7.4	9.7	7.7	9.5	7.7	9.5	7.6	9.3	7.5	8.8	7.5
7	.....	.....	.....	.....	.....	8.5	6.3	8.5	6.4	8.5	6.5	8.2	6.3	8.0	6.5
8	.....	.....	.....	.....	.....	.....	.....	7.5	5.4	7.5	5.5	7.3	5.6	7.0	5.5
9	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.5	4.7	6.5	4.8	6.3	4.9
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.0	4.3	5.7	4.2
11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.5	3.9

Tabulated figures show percent of total resistance in each step.

the torque demanded by the fractional and work elements of the load, the marginal torque being available for acceleration.

If the load torque is heavy, and it is desired to minimize the peak currents, the range between peak and valley currents will be small and a large number of steps will be required in the starting resistor. If a wide range is permissible, fewer steps will suffice.

Many factors control the degree of subdivision of the starting resistor. The type of motor has a bearing; a series or compound wound motor needs less steps than a shunt motor because the current inrush on each step is partially restricted by a quick increase of counter-voltage due to increased field strength. The size of the motor is an important factor; the larger the motor the slower the acceleration, the more serious the current peaks and the more steps ordinarily desirable. The type of control has an influence; more steps are desirable for manual than for magnetic controllers as the accuracy of operation is less perfect and arcing more serious. The character of the load has a bearing in that a heavy load renders the use of more steps desirable. If a machine carries a flywheel or otherwise has high inertia, the accelerating load may be heavy, even though the friction and work load elements are small. If armature resistance speed control is desired, an additional number of operating points may be of advantage.

Having determined the permissible current peaks, represented by I_2 in Fig 1, and the minimum or valley current necessary to overcome the load and provide for acceleration, the subdivision of the starting resistor to give a theoretical condition as shown in Fig. 1 can be computed, if desired, As previously explained, the total armature circuit resistance is evaluated to cause the current inrush I_2 when line voltage is impressed across this circuit. When the motor has accelerated to the point B on curve No. 1, the current I, is flowing. The counter-voltage at this instant is represented by the expression

$$\frac{I_2 - I_1}{I_2} \times \text{line volts.}$$

The resistor may now be decreased to such an extent that the total armature circuit resistance will pass the current I_2 when the line voltage minus the above evaluated counter-voltage is impressed upon it. This method of calculation may be repeated to determine further steps until the accelerating resistor is entirely cut out. This method of calculation assumes a constant field strength. With a series compound wound motor the counter-voltage increases to some extent with the current inrush at each step due to the increase in field ampere turns.

TABLE IV. PROPORTIONS OF ACCELERATING RESISTORS FOR USE WITH MAGNETIC STARTERS AND CONTROLLERS

Number of Steps	2		3		4		5		6	
Type of Motor	Shunt	Series	Shunt	Series	Shunt	Series	Shunt	Series	Shunt	Series
Step										
1	70	58	54	41	46	32	42	26	35	22
2	30	42	30	33	27	27	26	22	24	20
3	.....	.....	16	26	17	22	16	20	17	17
4	.....	.....	.....	.....	10	19	10	17	11	15
5	.....	.....	.....	.....	.....	.....	6	15	8	14
6	.....	.....	.....	.....	.....	.....	.....	.....	5	12

Tabulated figures show percent of total resistance in each step.

In view of the many factors influencing the subdivision of accelerating resistors exact calculations are not ordinarily attempted. Field conditions will vary from assumptions made for calculations and will vary from one time to another for a given installation. It is hardly feasible to subdivide accelerating resistors differently for each case. The practice has been fairly well standardized and subdivision is now based largely on tabulated

values. Table I gives the number of resistor divisions which will apply in average cases for full load starting duty where speed control is not required. This average practice may be departed from where conditions dictate.

An inspection of Fig. 1 shows that the resistor steps are unequal. The first step is comparatively large and succeeding steps decrease in size. Due to the several variable factors previously mentioned, it is customary to proportion resistor steps largely from tabulated data rather than to attempt calculation of each case.

Where speed control by armature resistance is desired the requirements for this purpose dictate, in a measure, the resistor step proportions. It is generally desirable to subdivide the total speed range afforded into a number of increments or points. Sometimes it is desired that these increments be equal. More commonly they are made proportionate, so that near full speed the increments are small and become coarser as the speed range increases. The latter method of proportioning fits better the requirements of starting duty with the same resistor.

Load characteristic also has a bearing. The load torque during acceleration may be constant, as in a line shaft drive, or it may increase with the speed, as in a fan or centrifugal pump application. If the torque increases with the speed the first resistor step may well be made relatively large and succeeding steps increasingly smaller, the taper being greater than in the case of a constant torque drive. This consideration applies especially to the subdivision of resistors for armature speed regulation duty for variable torque drives.

Due to the many elements involved somewhat different practices are followed by different manufacturers in the proportioning of accelerator resistors. Table III gives representative data for subdivision of accelerating resistors used either for starting or speed regulation duty with manual controllers. Two methods of subdivision are shown, one suited for ordinary starting duty and for speed regulation with a constant torque load, the other for speed regulation with a load whose torque decreases with the speed. Where used for speed regulation duty, the subdivisions shown give approximately proportionate, but not equal, speed increments. Table IV gives data representative of average practice in the subdivision of accelerating resistors used with magnetic controllers. It will be noted that the subdivision differs in the case of shunt and series motors.

Operating Features of Generating Equipment

General Care and Repair of Direct Current Generating Machinery. By V. E. Johnson

DIRECT CURRENT machines are surprisingly rugged—as is evidenced by the fact that many of them run for years, covered with filth, often damp, subjected to frequent excessive loads, and in general badly abused. Nevertheless satisfactory service under such conditions can not be reasonably looked for and failures are usually costly. Any direct current machine is particularly susceptible to damage from neglect, due to the fact that it has a commutator, hence is subject to all the troubles which arise from sliding contacts. Cleanliness is very important. The entire machine should be kept free from dust by means of bellows or compressed air and cleaned at intervals short enough to keep the accumulation down to a minimum. If compressed air is used for cleaning, care must be taken that it is dry, as water frequently collects in the air tank. Furthermore the pressure must not be too high—nor must the nozzle of the hose be held too close to the machine, as this will loosen the insulation on the coils and connectors. The commutator should be wiped often enough to keep all gummy accumulations away. A "hard" cloth such as canvas is better than soft linty cloth for this purpose, for with the latter lint often gathers in the brush rigging and gives trouble.

If the insulation on the coils and connectors seems to be drying out—often evidenced by small portions cracking off—a coat of insulating paint should be applied, either by painting with a brush or by spraying. This paint should be thoroughly dry before the machine is started up.

Oil, or any lubrication for that matter, should be used very sparingly on the commutator. In the first place it carbonizes on the surface and impairs commutation. It also causes flying particles of carbon or other dirt to adhere to the bars. It causes holes in the mica between the bars, due to the fact that commutator mica is "built up" from thin flakes cemented together, and oil, in time, weakens the binder. This process of pitting is cumulative in character—and when once started proceeds quite rapidly. The remedy is carefully to scrape away the carbonized mica and then to fill the cavity with commutator cement.

Undercutting

If the commutator is subject to "high mica" the quickest solution is undercutting. This is done by means of a hack saw blade or similar device. A very slight cut is sufficient—indeed a shallow groove is to be preferred to a deep one, as the latter accumulates dirt. The edges of the commutator bars should be beveled slightly. If this is not done, there is a tendency for the brushes gradually to "drag" the edge of the bar across the slot, and so eventually cause a short. Furthermore—with beveled bars—dirt will not accumulate in the slots so readily.

In this connection, it should be noted that slotting is not always advisable. Under conditions which are not clearly enough understood to be given as fixed rules, undercutting the mica aggravates the commutator trouble. This, however, is the exception and not the rule.

Selection and Care of Brushes

Brushes should be kept clean and free in the holders. The "pigtails" should be checked to see that all are connected. The brush pressure should be kept uniform.

It is not good practice to mix the kinds of brushes on a machine; that is, they should all be of the same quality. If this rule is not observed, the current division between the brushes will be affected and sparking may

result, due to the lower resistance brushes taking more than their share of the load. Sometimes, indeed, it is desirable to combine with lubricating brushes others having more abrasive qualities to keep the mica worn down. In that case, all the studs of one polarity should have similar brushes.

Usually all the experimenting required for the proper selection of brushes has been done at the factory. The characteristics of the brushes used have a great deal to do with satisfactory operation and it is inadvisable to deviate from the standard set by the maker. A very small difference in brushes is often sufficient to change a sparkless machine into one having bad commutation.

It is, generally speaking, inadvisable to entrust the repairing of electrical machinery (or any machinery for that matter) to inexperienced men. There are, however,

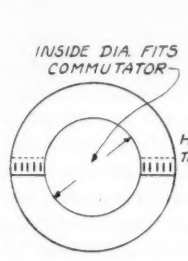


FIG. 1

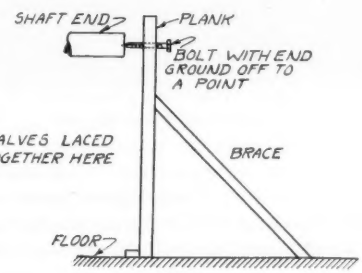


FIG. 2

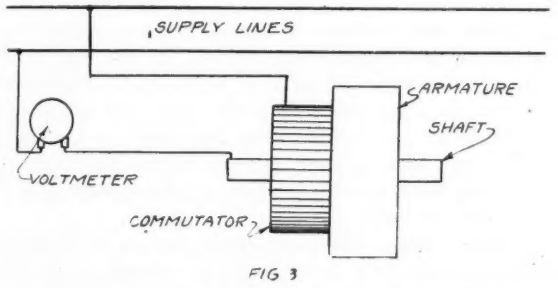


FIG 3

FIG. 1. A SHIELD OF CARDBOARD CUT TO THIS SHAPE PREVENTS DUST AND COPPER PARTICLES FROM ENTERING WINDINGS

FIG. 2. ARRANGEMENT FOR PREVENTING SIDE PLAY OF ARMATURE

FIG. 3. METHOD OF MAKING INSULATION TEST

a few simple repairs that can be made without the aid of a regular repairman.

If an armature coil ground to the frame and it happens to be the top coil in the slot—the repair can be quite easily made. Remove the band wires, and raise the damaged coil, put a piece of flexible mica around it and replace. If the damage is to a bottom coil, this would necessitate the lifting of a number of coils and should not be undertaken by an amateur except as an emergency measure. Sometimes a piece of mica can be forced between a coil and the iron without removing it from the slot. This will serve as a temporary cure, if the ground happens to be in the sides of the coil.

A damaged commutator can seldom be repaired without removing it from the machine. This means the unsoldering of all the connections to the "necks" and is a pretty big undertaking. Pitted mica can be repaired as described above.

If the commutator is rough or out of round, or has high bars, the remedy is either grinding or turning. Either of these operations can be performed satisfactorily by a machinist, leaving the armature in its bearing. For grinding the armature should be run at full speed or nearly so, as this throws the copper dust out of the armature but turning, must, of course, be done at a low speed. It is advisable to place some sort of a shield around the commutator necks so as to prevent the copper particles from getting inside of the armature. A piece of stiff cardboard shaped like as shown in Fig. 1 and tied to the brush rigging makes an effective shield.

In turning or grinding, some means must be used to prevent the armature from playing endways in its bearings. Usually a wooden frame or brace as shown in Fig. 2 can be rigged up with very little trouble.

If a generator has moisture in it, this can be dried out by running it on a short circuit, leaving the series field disconnected, and separately exciting the shunt field to a very low value. This should be done carefully so as to avoid damaging the insulation. To determine when the generator is dry and ready for use an insulation test should be made. This is easily done, the only instrument required being a voltmeter with a known resistance and a suitable source of direct current. Connect the voltmeter as in Fig. 3. Read the voltage across the line and then the voltage when touching lead to the commutator as shown. Now apply formula:

$$R = \frac{r\,(V - v)}{v\,(1{,}000{,}000)} \text{ where}$$

R = insulation resistance of machine, in megohms.
V = voltage of line—preferably 500 v.
v = voltage through insulation as shown in Fig. 3.
r = known resistance of voltmeter (usually marked in case).

The resistance R so obtained should be at least 1 megohm, but it is advisable to check the value of R during the drying out process and continue until it has reached a fairly constant value.

Tempering Ice Reduces Shattering

TEMPERING ice after it has been drawn from 13 deg. or 14 deg. F. brine is generally considered essential for the production of good, tough ice. In plants of more than one tank, the puller can pull a group of cans and leave them suspended to drip over the can well while he works on another tank. This helps the tempering and assists in keeping the tank top clean and dry. The cans are then taken to the dumping platform or the tank top adjacent, where the cans are detached from the crane and left to temper for sometimes as long as 2 hr.

During this period of tempering, the ice can and cake which have been withdrawn from the brine tank at some 13 deg. or 14 deg. F. have an opportunity to take up by radiation from the air at 65 deg. F. or above, some of the sensible heat from 32 deg. down to 13 deg. F. This prepares it for the thawing or dip tank so that its bath in 60 deg. F. water or so is not such a sudden temperature change of wide temperature difference. This eliminates to a large extent the shattered cakes at the dump so often caused by improper tempering and produces a cake which is tough and ductile rather than one that is hard and brittle.

Reproducing Lightning with Two Million Volts

DETAILS AND THE UNDERLYING PURPOSE OF THE RECENT SPECTACULAR TESTS AT THE PITTSFIELD WORKS OF THE GENERAL ELECTRIC CO.

IN THE PRODUCTION of high voltage electricity, approximately the power of lightning, which has caused so much interest in scientific circles and indeed startled popular imagination, the practical significance of the tests have to a certain extent been lost sight of.

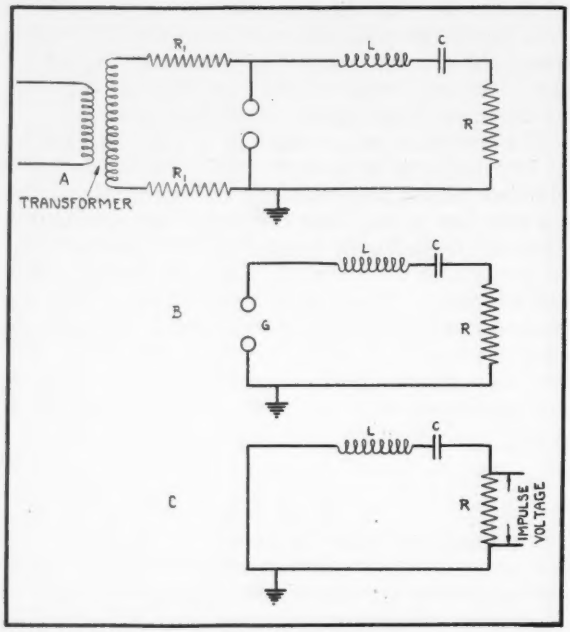


FIG. 1. IMPULSE GENERATOR CIRCUIT

Two million volts is a staggering figure. Man-made lightning is a phrase to conjure with. Yet the engineers at the Pittsfield Works of the General Electric Co., who spent years of study in the production of these highest known artificial electric pressures, did this not simply to produce a pretty picture of an electric arc or an artificial thunder storm with all the appendage of pyrotechnics but they had a very definite end in view. This was the devising of improved methods for protecting electrical systems from the damaging effects of real lightning particularly on long transmission lines carrying power from mountain waterfalls to cities miles away.

Some of the things which mean much to the engineer in considering the phenomena of lightning were described before the American Institute of Electrical Engineers by F. W. Peek, Jr., who conducted the recent spectacular tests:

During a thunder storm, lightning voltages that reach the transmission line appear across insulators, transformers and other apparatus at the extremely rapid rate of millions of volts per second. With this rapid rate of application the voltage may reach a very high value of a microsecond (millionth of a second). Hence, since there is always a delay or lag in the breakdown of insulation, quite peculiar effects result from these voltages. For instance, some remarkable phenomena that take place are: Much higher lightning voltages are usually required to jump a given distance than voltages at normal operating frequencies; conductors at normal frequency voltages are often good insulators for lightning voltages; water may be punctured like oil; the wet and dry spark over voltage of insulators are equal; the strokes can be obtained that increase at the rate of 50 million million volts (50 trillion) per second. The power lightning discharge has a decidedly explosive effect, etc. In addition to the characteristics just mentioned, a study has also been made of the change in voltage and shape of a lightning wave as it travels over a transmission line at the velocity of light.

In order that a laboratory study may be of practical as well as theoretical interest, it is necessary to be able to reproduce lightning voltages in the laboratory on a large scale and of known characteristics. This investigation was started some years ago with a 200-kw. generator, which has been added to from time to time, until now 2,000,000 v. are available and single lightning

FIG. 2. DAYLIGHT VIEW OF THE LITTLE VILLAGE USED IN THE 2,000,000-V. LIGHTNING EXPERIMENTS

FIG. 3. A 2,000,000-V. LIGHTNING STROKE ON THE MINIATURE VILLAGE

is of the order of millions of kilowatts. It is believed that this generator closely approximates voltage and other conditions that usually occur on transmission lines. The lightning voltages used in our investigation were far in excess of any heretofore produced in a laboratory.

Method of Producing Lightning Discharges

Methods employed in making these tests have been described in the Journal of the American Institute of Electrical Engineers as the development along these lines progressed. For convenience, a brief description is given here. The circuit is shown in Fig. 1A. The gap G is set at some desired voltage. The transformer voltage is increased until discharge occurs. At that instant the condenser C is charged up to a voltage corresponding to the gap setting. A dynamic arc forms at G and holds. This acts as a switch and the condenser discharges through the known inductance L and resistance R. The circuit that produces the impulse is shown in Fig. 1B or is, in effect, that shown in Fig. 1C. The condenser discharging through the known resistance and inductance causes a transient current that can be readily calculated. This current produces a transient voltage drop across R. This is the impulse voltage used in the test.

In its present form, the lightning generator at the Pittsfield high voltage engineering laboratory consists of a condenser of 480 glass plates arranged in cells or frames with 10 plates in series in each frame. The capacity per plate is 0.0112 microfarads; per cell, 0.00112 microfarads. The cells are readily arranged in multiple and series combinations as required. Three cells in series on each side operate satisfactorily at a million and a half volts maximum to ground. In the "set-up" described, a series of tests were made up to 1500 kv. maximum. The energy available for the discharge is proportional to $\frac{E^2C}{2}$. The inductance L is that formed by the rectangular circuit. The resistance R is a water tube of 5000 ohms. This particular arrangement gives the wave shown in Fig. 6.

Photographic studies have shown the lightning spark over of insulator strings that are of such length as rarely to spark over in practice even in bad lightning country. The photographs of the flashes show all the characteristics of lightning such as a zigzag path, side flashes and the like. These studies are of interest for they indicate a certain protection which must or should be taken in practice. With such voltages and current possible therefore it is practical to investigate the protective value of ground wires and also lightning rods. Such an investigation as this is the one now under way.

Along with the production of 2,000,000-v. lightning voltages, further studies of the original production of high voltage at 60-cycle frequency have been continued. Even if transmission at one million volts is not definitely in sight at the present time there are of course, many uses for such high voltages in the laboratory, from the

FIG. 4. LIGHTNING BOLT ABOUT 10 FT. LONG. IT WILL BE NOTED THAT THIS BOLT HAS ALL THE CHARACTERISTICS OF NATURAL LIGHTNING

FIG. 5. THE DESTRUCTIVE 1,200-000-V. LIGHTNING BOLT SUCCESSFULLY CLEARS THE PORCELAIN INSULATOR, EVEN DURING HEAVY RAIN STORMS

standpoint of research. But it may not be out of place to indicate just what are the possible uses of a million volts in practical transmission.

The conductor would probably be about 6½ in. diameter. If it is assumed that this is a hollow tube with copper equivalent to a 1-in. diameter rod, it is possible to transmit three million kilowatts a thousand miles with about 12 per cent loss and a million volts at each end. If 5-in. tubes were used, there would be very little loss in fair weather; but during a rain storm the loss would be of the order of 1000 kw. per mile. The striking fact that this brings out is the large amount of power necessary to make such a line economically desirable. It also emphasizes the enormous size of the apparatus units necessary. If present practice were followed, 1,000,000-kw. transformer units would be necessary. This

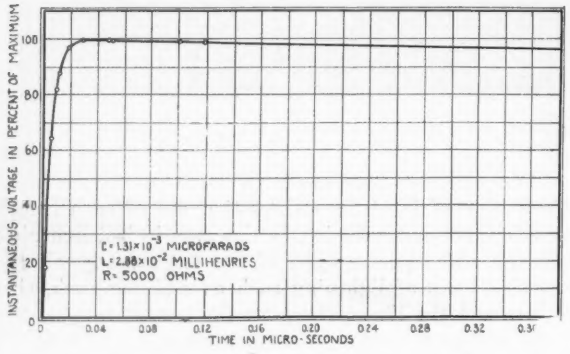


FIG. 6. WAVE SHAPE OF LIGHTNING VOLTAGE

would probably mean erecting in the field. The problem of size and transportation become greater than the problem of voltage. But, it is only a little over 10 yr. ago that the 200,000-v. line was in a similar laboratory stage as the 1,000,000-v. line discussed here.

Should Engineers Specialize?

By Jack L. Ball

Now and then we meet an engineer who seems to stand out more prominently than some of his fellows. If we could decipher his expression on certain occasions, it might tell us, perhaps, that this man is a specialist, a power plant man who is an expert in one certain thing connected therewith and is aware of his capabilities.

In power plant engineering, it is quite possible to know a little about every phase of the work, but it's just a little unreasonable to expect one man to be a master or a specialist of every detail. We find in small plants that the engineer is supposed to be superhuman and in many instances he certainly does try to live up to his reputation. His work includes everything from slotting commutators to raising boiler stacks. An error of judgment often goes by unnoticed.

Time brings events and reverses the procedure of power plant operation. It is rapidly eradicating the general utility engineer, that is, the man of many jobs. Science is gradually getting a firmer foothold which necessitates more and more a specialized knowledge of certain important factors connected with power plant operation.

Perhaps the greatest field of opportunity at the present time is combustion. There are thousands of men engaged in this profession from water tender to combustion expert, but no means have been devised to convert all the great latent energy contained in coal into mechanical work. In late years, important gains have been made, but the complete utilization or harnessing of all the power contained in coal is something still far in the future.

From coal bin to switchboard, opportunities to specialize are many and jobs are waiting for men who actually know how to do certain things well. Universities are graduating engineering students by the thousands. Those few who specialize mostly make good; those who generalize are in many instances discarded or in time take up some other kind of endeavor. The man who would succeed must first decide just what he would like to do. The initiative must not come from heritage or from someone's suggestion, it must come from honest desire. If, after you have looked over the field, you decide that lubrication attracts you; if your interest is real and you feel that you will like this particular kind of work, and, lastly, if you will dig right in with an honest-to-goodness enthusiasm, the sky is the limit.

You cannot be successful in any vocation unless you give your job just a little more than its due. The most disgusting thing in existence is for a man to tell you how interested he is in his job when you know that his enthusiasm is forced. It always puts one in mind of a fake stock salesman who won't risk his own money.

Fortunately, there are mighty few power plant men who practice imitation interest. Those who do are found out sooner or later. Find out what a man does with his leisure time and you can usually estimate his value to his employer; further, you can form a fairly accurate opinion as to the condition of his plant.

Imitators are usually misfits and should their lives be traced back it is oftentimes found that at the critical period, at the age when a man should have decided what his life's work should be, they were undecided, didn't know exactly just what they wanted to do. They simply floundered around without making any honest effort to seek out some kind or class of work that really suited their fancy.

I am acquainted with an operating engineer whose case exactly fits the preceding. Up to the age of 30, he worked at everything from farming to mining coal. He was given an opportunity to fire extra in a boiler-house. He felt at this time that he had reached the age where he had to stick to something, although I have heard him say that he hated the work then as he does now. A certain degree of independence and good wages are the only attraction he finds in his work. He has been more or less of a success, but I'm afraid that the mental cost has been high.

To any young man who is contemplating power plant engineering as a means of earning a livelihood, I would say, generalize to a certain extent, but after you have reached a certain limit, specialize, or, in other words, become an expert in some certain thing.

Jack L. Ball.

Amsterdam, O.

Oil Engines Gain Favor of Central Stations

MARKED TENDENCY TOWARDS INCREASED USE OF DIESEL ENGINES IN LARGE UNITS ACCORDING TO PRIME MOVERS COMMITTEE OF N. E. L. A.

ONE feature of this year's Prime Movers Committee Report of the National Electric Light Association is the attention given to the subject of oil engines, and the possible use of such units for central station work.

This active interest is in all probability due to the availability of units in ratings up to 3000 hp., which makes their use feasible in what might be termed medium sized central stations. Previous to the development of such ratings, it was necessary to use a number of smaller units to secure a station capacity of any consequence.

As pointed out by the Committee, the fuel economy of the oil engine has been recognized; but the deterring factor, other than limited ratings, has been the belief among operators that the maintenance cost on oil engine plants is excessive. In order to come to some conclusion on this latter point, the committee made extended investigations of operating costs including maintenance expense.

In the accompanying tabulation is shown a summary of the experience of several companies operating Diesel plants. Several of these stations have been in operation for 10 yr., and the companies making the reports consider this type of prime mover entirely satisfactory. The costs shown are for a period of 3 yr., but since the inflated period of 1920 and 1921 is included, the committee points out that the figures are somewhat misrepresentative in several places.

With regard to the increasing interest in oil engines, the committee makes the following comments:

"As we review the operating results for Diesel engines, the progress of Diesel builders, and the great spread of new and important installations of engines during the past year, we cannot help but feel the increasing prominence of this type of prime mover. Engineers outside the field are beginning to recognize the zone of power generation which now belongs to the oil engine. Diesel engines of all types have, in the past,

Item	DATA	STATION A	STATION B	STATION C	STATION D	STATION E
1	Number, Size and Kind of Diesel Units	3-500 h.p. M&S Diesels 3-310 kw. rating G. E. Gen.	4-225 h.p. B&S Diesels *1-500 h.p. M&S Diesels 2-300 kw. rating G. E. Gen. 1-310 kw. rating G. E. Gen. **1-250 h.p. Prime Semi-Diesel 1-150 kw. G. E. Gen.	3-225 h.p. B&S Diesels 1-300 kw. rating G. E. Gen. 1-150 kw. rating G. E. Gen.	1-500 h.p. M&S. Diesels 2-225 h.p. B&S Diesels 1-170 h.p. B&S Diesels 1-310 kw. rating G.E. Gen. 2-150 kw. rating G.E. Gen. 1-125 kw. rating G. E. Gen.	1-500 h.p. M&S Diesels 1-310 kw. rating G. E. Gen.
2	Total Diesel Plant Capacity, kw	930	750–910***	450	735	310
3	Grav. of fuel oil, °Be. (average)	22–26	22–26	22–26	22–28	22–26
4	B.t.u. per lb. of Fuel (average)	19,000	19,000	19,000	19,200	19,000
5	Station Output kw.-hr.	18,021,930	6,787,766	3,497,716	6,372,788	5,650,010
6	Max. Hour Generated kw.-hr.	1,060	740	460	600	350
7	3 Yrs. Max. Peak, kw.	1,090	780	483	620	350
8	Station Load Factor %	73.7	33.25	29.50	33.0	69.4
9	Fuel used, Total bbls.	38,813	20,003	10,963	16,320	13,359
10	Lb. fuel per kw.-hr. Output	.675	.925	.985	.804	.741
11	B.t.u. /kw.-hr. Output	12,820	17,580	18,720	15,430	14,090
12	Lubricants in Gals. /kw.-hr. Output	.00098	.00240	.00232	.00184	.00092
13	Engine Maint. Cost /kw.-hr. output, Mills	3.23	6.91	9.05	7.95	4.60
14	Fuel Cost /kw.-hr. output Mills	3.98	5.86	5.90	5.75	4.51
15	Lubricant costs /kw.-hr. Output Mills	.410	1.79	1.21	1.08	.640
16	Total Maint. costs /kw.-hr. output mills	3.39	7.40	10.01	8.65	4.94
17	Misc. Supplies /kw.-hr. output mills	.492	1.00	.971	.699	.726
18	Labor Cost /kw.-hr. output mills	2.17	4.40	5.27	3.65	2.43
19	Production cost /kw.-hr. output mills	10.442	20.45	23.361	19.829	13.246
20	Number of Employees (average)	6	7	3	5	3

**Not used since 1920.
*Installed 1922.
***Increased due to new unit.
NOTE:—The Diesel engines at the stations represented in the above tabulation vary in age from 8 to 17 years. All of these engines have been giving continual service with the exception of the time lost for regular maintenance and repair periods.

OPERATING RESULTS OF DIESEL ENGINE PLANTS COVERING A THREE-YEAR PERIOD ENDING DECEMBER 31, 1922

established themselves as important units for the power industry, and it must be acknowledged that the future holds promise for the oil engine as an increasing competitor with steam equipment of many kinds.

"While the future of the Diesel engine is apparently safely established, yet the time has come when its performance and past history as a prime mover must stand the test of close analysis. Aside from the importance of operating economy and moderate maintenance cost, there is also a demand for simplicity and reliability. As a rule, all Diesel engines are easy to operate if the engineer understands the principles of operation and has had some experience with this type of engine. Simplicity of construction and the smallest number of moving parts are of great importance, especially when the class of labor which is found in the average power station is considered. Reliability is essential, since every engine must often be ready to operate for long periods. Working parts must be accessible so that necessary repairs can be made in short time, and so that such parts can be easily and cheaply renewed.

"The continued, reliable, non-stop operation of a modern type Diesel engine depends on the care of operation and the kind of engine installed. The successful operation of the engine includes maintaining it, and the maintenance involves skilled mechanical work of high grade. Records showing high maintenance costs for oil engines are facts; but, fortunately, many cases represent avoidable accidents and lax maintenance programs.

"Engine builders have recognized the value of selecting the best engine materials, of perfecting engine details, and of employing expert workmanship in order to eliminate any undue personal responsibility for poor performance. Yet engine maintenance routine may not be overlooked. Time and labor for proper care and attention of prime movers must be allowed. Maintenance problems must be recognized and then met fairly with constructive criticism if progress is to be made. When this time comes, the Diesel engine user, with the cooperation of the builders, will become a master of his units and engine maintenance costs will doubtless be greatly reduced."

Two Generators Direct Connected to Turbine

SINGLE TURBINE UNITS MOUNTED BETWEEN AND DRIVES TWO GENERATORS WHICH ROTATE IN OPPOSITE DIRECTIONS

AS FAR BACK AS 1912 Birger Ljungstrom built and placed in operation a radial flow turbo-generator of interesting construction in that the turbine was located between two generators such that the turbine and generator shafts were on the same horizontal center lines.

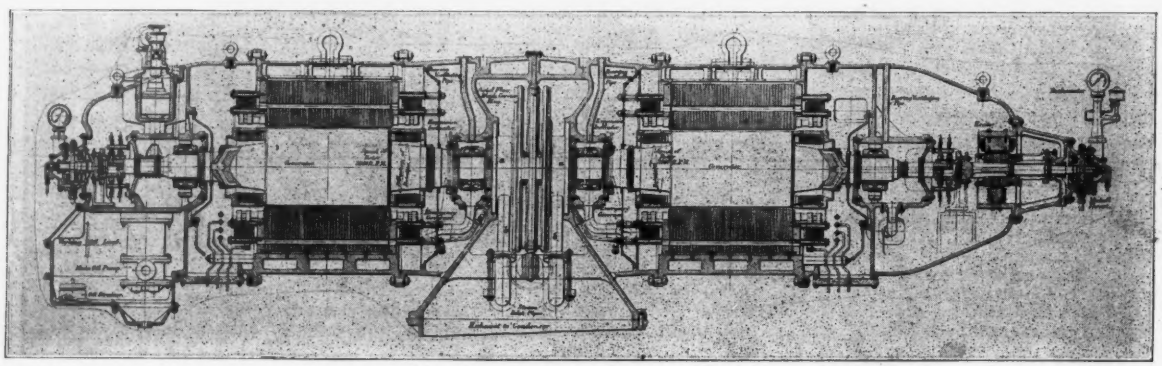


FIG. 1. LONGITUDINAL SECTION OF 5000-KW. BRUSH LJUNGSTROM STEAM TURBINE

Recently The Brush Electrical Engineering Co. of England has placed in operation a 5000-kw. Brush-Ljungstrom turbo-generator of the same general design as the first unit. The turbine consists of two rotors which revolve in opposite directions on separate shafts. Steam enters at the shaft center and flows radially through rings of horizontally placed blading, alternate rows of blading being attached to the right and left-hand blade carrier rings. Each carrier ring or rotor is securely fastened to its shaft which extends through a packing gland and forms the shaft for one generator.

Modern practice calls for a vacuum over 29 in., this means that a large volume of steam must be passed through the last row of blades. This difficulty has been overcome by fitting radial blades to the periphery of the rotors, so that the steam after flowing radially must turn through a right angle and pass horizontally through the final row of blades. This construction has greatly reduced restriction losses of the outgoing steam.

Springs support the generators, the casings of which are secured to the turbine casing, this is essentially a cantilever construction for the generators. The turbine casing is fastened directly to the condenser, which in turn is supported on springs.

In passing through the rotor blades, the steam produces a heavy axial thrust. This is balanced by the counter pressure of the steam which is simultaneously leaking through balancing chambers. Any thrust not provided for in this way is taken care of by a thrust bearing provided at the end of each generator shaft. The glands where the rotor shafts pass through are designed so that air is drawn through the last constriction by an injector action. The air thus admitted and any steam which may leak past the gland are discharged to a small auxiliary condenser. Repeated measurements have shown that this gland leakage amount to from ¾ to 1 per cent of the total steam passing through the blades.

Excitation is provided from an exciter mounted at the end of one generator shaft. The oil pumps and main governor occupy a corresponding position on the other generator shaft. The main governor is carried on the end of the governor spindle which is driven by spiral gearing from the generator shaft. The lubricating oil pump of the gear type is completely submerged in oil and attached to the lower end of the governor spindle. Oil is delivered at a pressure of 30 lb., which is the pressure needed to operate the stop and governor relay valve; for lubrication purposes, a pressure of 5 lb. per sq. in. is sufficient.

Emergency Oil Pump Is Steam Driven

For emergency service, a direct-acting steam-driven pump is provided; it is permanently connected to the steam service and automatically comes into action should the oil pressure fall to such a point as to endanger the operation of the unit.

Emergency governors are fitted into the generator shafts. Each governor consists simply of a spring loaded plunger, mounted in a hole drilled through the shaft.

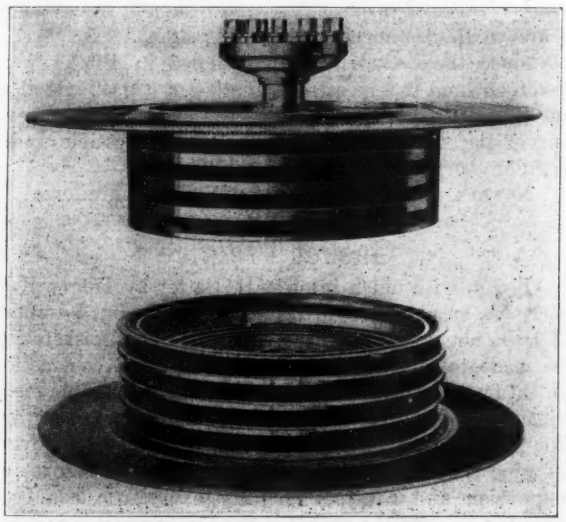


FIG. 2. SHOWING AXIAL BLADING AND MANNER IN WHICH HORIZONTAL BLADE RINGS OF THE TWO ROTOR TELESCOPE

The center of gravity of this plunger does not co-incide with the safe center; when the turbine is running centrifugal force tends to make the plunger move out and thus compresses a spring; upon overspeeding, the force of the plunger overcomes the resistance of the spring, a trigger is released and the bypass to the governor relay is opened which in turn causes the stop valve to close.

It is claimed that both floor space and weight are in favor of this type of turbine. As to economy, some recent tests have shown a steam consumption at rating of 10.36 lb. per kw.-hr.; this was under the conditions of 166 lb. ga. steam pressure, 289 deg. F. superheat and 28.95 in. of vacuum. The efficiency at the switchboard was 76.4 per cent, whereas the overall turbine efficiency was 80.4 per cent.

This description has been taken from a report on this turbo-generator published in "Engineering" of London.

Some Low Temperatures*

By W. F. Schaphorst

ALL OF US are interested in low temperatures, particularly temperatures at which such substances as mercury, ammonia, carbon disulphide and oxygen freeze and become solid.

I have averaged the results of freezing points obtained by various authorities and have converted the figures from Centigrade into Fahrenheit because most of us are more familiar with Fahrenheit than we are with Centigrade. My results which have been averaged, computed, and checked with extreme care are as follows:

Carbon Tetrachloride	—9.2
Mercury	—38.0
Chlorbenzene	—49.79
Chloroform	—82.8
Ammonia	—107.86
Carbon Dioxide	—109.4
Toluene	—139.72
Methyl Alcohol	—144.1
Methyl Chloride	—145.1
Carbon Disulphide	—169.94
Ether (Second Mod.)	—176.98
Ether (First Mod.)	—190.36
Oxygen	—297.29
Hydrogen	—430.00

How the Absorption Refrigerating Machine Works

Operation of the absorption type refrigerating machine is based on the fact that pure water readily absorbs, and holds in solution, ammonia gas. The quantity of ammonia it will absorb and hold depends only on the efficiency of the mixing device, the pressure of the gas and the temperature of the solution of aqua ammonia. Strong solution aqua ammonia is pumped through the exchanger into the generator. Steam coils heat the solution and drive out the ammonia gas, which is passed through the rectifier or moisture separator, into the condenser. This operation is similar to the discharge stroke of the compression machine and accomplishes the same result, and the same number of pounds of high pressure ammonia gas must be discharged into the condenser, cooled and liquefied per hour per ton of refrigerating effect. It is then conducted to the expansion coils through the feed valve, where it is allowed to evaporate, as in the compression system, gathering heat from the objects to be refrigerated. Since strong aqua liquor is being continually pumped into the generator and the gas driven off to the condenser, a continuous supply of weak liquor results, which passes out of the generator, through the exchanger and weak liquor cooler to the absorber, through a regulating valve for a fresh charge of ammonia gas. The weak liquor enters the absorber through an injector device, drawing gas from the cooler and absorbing it and this process compares with the suction stroke of a compressor. The resultant strong aqua ammonia is taken from the absorber by the aqua pump and forced through the exchanger heater to the generator. The steam coils heat the liquor, distilling off the gas, and the process is repeated continually.

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A Valuable Water Cooling Kink

HERE IS a kink that may prove to be worth many dollars to the person who considers it safe to make a water cooler along the lines indicated in Fig. 1.

The writer was once connected with a company that made some water coolers in this way. The method was the first one that entered the head of the chief engineer and it looked perfectly logical to the rest of us. No doubt it has been used many times and perhaps it has been used successfully. I saw the method recommended in a refrigerating paper not long ago as being

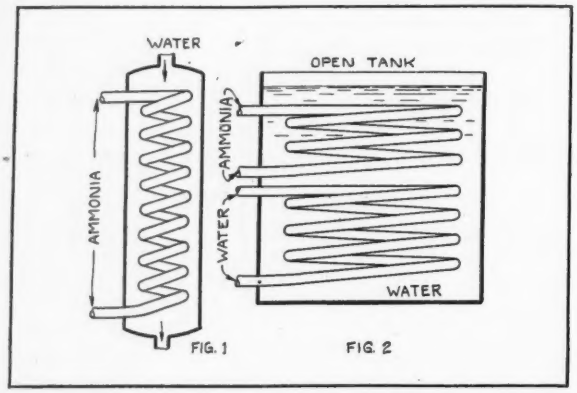

FIG. 1. THIS TYPE OF WATER COOLER MAY BURST, DUE TO FREEZING OF WATER

FIG. 2. OPEN TANK OF THIS TYPE LESSENS DIFFICULTY ENCOUNTERED BY USE OF TANK SHOWN IN FIG. 1.

a good, dependable method,—but, Beware! As shown, an ammonia coil is placed inside of a closed cylindrical tank for cooling the water. The water is supposed to be kept in continual motion, and if a sufficient quantity is circulated the method may be perfectly safe, but there is danger that circulation will not be maintained or that the temperature of the water will reach such a low point that the water begins to freeze, and when it begins to freeze, look out. The tank will burst due to the freezing and it will be found very difficult and costly to repair.

Figure 2 illustrates a much better method—a method that is practically foolproof. The ammonia coils are placed in an open tank, as indicated, close to the top of the water level. Note that the liquid in the open tank is not brine but is plain ordinary water. This water can freeze if it wishes to, but of course it will freeze only at the top. The tank is made large enough so that it is not likely that the water will freeze clear over to the walls of the tank, consequently there will be no rupture. The coil being close to the top of the water where the water is always warmest, proper circulation is maintained. That is, as soon as the water cools it moves downward and the warmer water comes upward. The cold water therefore surrounds the lower coil, which is the water coil. The temperature of this surrounding water will never be lower than 32 deg., consequently the water in the lower coil will not freeze and of course the water surrounding the lower coil will not freeze as all of the freezing takes place at the top. In this way, circulation of water through the lower coil is always possible and there will be no clogging. In Fig. 1 in case the water should freeze solid, there would be no circulation of water.

Since the cylindrical tanks shown in Fig. 1 were taken out and the open tanks similar to Fig. 2, installed, no difficulty from freezing has been experienced. Freezing of the water in the lower coils is impossible under regular working conditions.

Newark, N. J. W. F. SCHAPHORST.

Gasket Practice

I READ with much interest the letter by Henry Bohmer, Jr., on page 390 of the April 1 issue, but I wonder if he is not mistaken in his contention that gaskets can be made to take care of all expansion and contraction in saturated steam lines. I have had considerable experience with gaskets of all kinds and have never yet found a long steam line that did not require some form of pipe bend or expansion joint that had to absorb the expansion and contraction. My experience has been that the thinner the gasket is the better when it is made of asbestos, sheet rubber, or corrugated metal; the thinner it is the more likely it is to remain tight. These gaskets should, of course, be bolted up as tight as possible without straining the bolts beyond their elastic limit.

Regarding the length of wrenches I would say that I have seen wrenches of nearly all lengths made for ½-in., ¼-in. bolts, etc. I do not believe that there is a standard for wrench handles although it does seem reasonable, as Mr. Bohmer states, that there should be one.

Atlantic Highlands, N. J. JOSEPH SCHMITZ.

MR. BOHMER in his article on gaskets claims that it is not necessary to tighten a joint on a thick, flexible metallic gasket, as tightly as on a thin, non-flexible one. In many years' experience I have found that the thinner the gasket in a steam-joint, the better it would hold. In the first place, the thick gasket presents a greater area against the pressure and therefore is more likely to blow out than a thinner one is. Having tried many different makes of patent gaskets, I have found that

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those made of the same expansive qualities as the flanges themselves gave the best results. Many patent gaskets which I have tried would hold a joint steam tight when the full boiler pressure was on, but would leak badly when the pressure was lowered. Given a steam pipe in perfect alignment and smooth flanges properly bolted up with the thinnest possible gasket, I feel assured of no trouble with leaking joints. It is bad practice to depend upon steam-pipe joints to do the work of expansion joints.

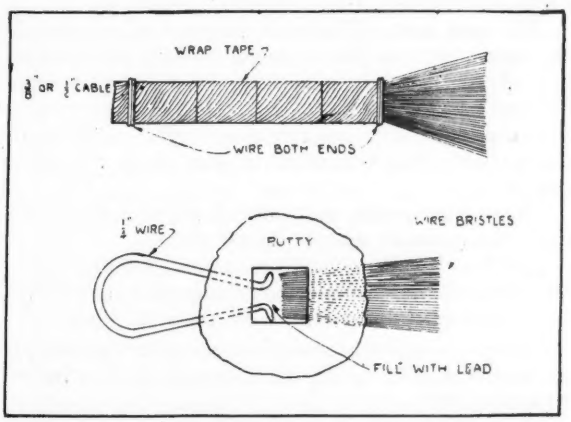
Addition to the length of a wrench handle is sometimes necessary but should only be used by an experienced mechanic. There may be a strain on the pipe, or a tight thread in the nut, or on the bolt, which would make it hard to pull up. In any case, judgment must be used to avoid stripping the thread or breaking the bolt.

M. M. Brown.

Camden, Me.

Making Steel Scratch Brushes

Often a stiff brush comes in handy around the plant. The simplest way to make one is to take a piece of ⅜-in. or ½-in. wire cable 7 or 8 in. long, wire it at two places so it will not get out of shape, wrap a little tape around it, flatten up one end and cut it square. It will answer the purpose for rough work on stone, concrete, rough castings, etc. For finer work, a wire brush can be easily made with a little bunch of fine wire. Take a



METHOD OF CONSTRUCTING SMALL STEEL BRUSHES

chunk of putty nearly as big as one's fist, make an impression about 1 in. square and ¼ in. deep. Lay the wire bristles in the putty together with a handle made of a piece of ¼-in. wire; pour in lead to fill and when cool trim off with a file.

Johnnie, Nevada. Chas. Labbe.

Stuffing-Box Packing Kink

For a large, marine-type engine, packing the rod stuffing-box is sometimes a nasty trick. The box is usually deep and unhandy to reach and, if the packing is a tight fit, considerable force is necessary to get the box properly filled. In such a case, a wood split bushing such as is supplied with wooden pulleys has been used satisfactorily, or if one of the right size is not available a substitute can be easily made.

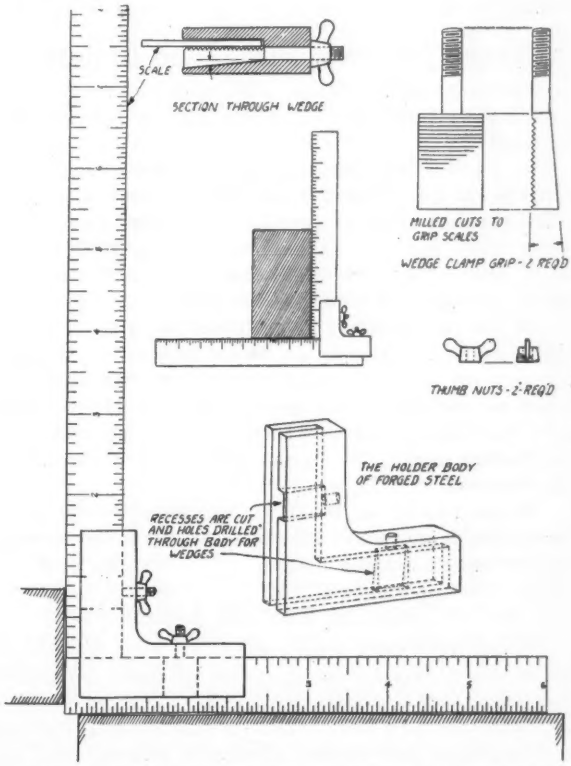
Bore a hole the size of the rod in a piece of wood and work down the outside of the block so as to be a loose fit in the stuffing-box. Then cut in halves lengthwise. The block should be long enough so that the gland will not strike against the studs when forcing home the first ring of packing.

After placing a ring of packing in the end of the stuffing-box, put the wood bushing around the rod and hold it in place while a helper turns the engine over by hand until the gland comes up and pushes the packing into place. With care any style of packing can be put in as tight or as loose as is desired.

Toronto, Ontario, Can. James E. Noble.

Machinist's Square Made by Combining Two Scales

It is possible to use a fixture which will combine two straight edged machinist's scales into a serviceable square, suitable to use for purposes where the more accurate small square is too fine a tool to sacrifice on rough work as castings, forgings and heated metal parts or when the usual square is too short to gage the parts being worked on.

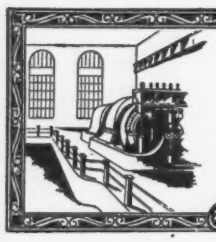

SCALE
SECTION THROUGH WEDGE
MILLED CUTS TO GRIP SCALES
WEDGE CLAMP GRIP - 2 REQ'D
THUMB NUTS - 2 REQ'D
THE HOLDER BODY OF FORGED STEEL
RECESSES ARE CUT AND HOLES DRILLED THROUGH BODY FOR WEDGES

PARTS AND ADAPTATION OF IMPROVISED MACHINIST'S SQUARE

A suitable attachment for this purpose is shown in the accompanying illustration. It is a forged steel holder, fitted with clamp screws for holding two scales with the ends adjacent or overlapping.

This is a simple device, and the same holder or clamp will serve for various lengths of scales, varying the size of the square to meet conditions.

Washington, D. C. G. A. Luers.



PROBLEMS IN OPERATING POWER EQUIPMENT

What Size Spray Pond Will Be Required?

I SHOULD like to have the opinion of the readers of Power Plant Engineering in regard to the size of a cooling pond necessary to take care of the circulating water for a 500 hp. cross compound Corliss engine using 17 lb. of steam per hp.-hr. This engine is equipped with a surface condenser with which we are able to maintain a vacuum of 23 in. At present cooling water is supplied by a forced draft cooling tower which cools the circulating water from 118 to 84 deg. F. We want it to go to the tower and substitute a spray pond.

What size pond will be required? How many spray nozzles will I need? The make-up water runs about 60 deg. F. C. W. F.

Water Tube vs. Fire Tube Boilers

WILL YOU kindly advise me whether a water tube or fire tube boiler would be the best suited for my purpose?

We contemplate installing a new uniflow engine to drive a 400 kw. generator and we will need a greater boiler capacity than we have at the present time. Our boiler room space is limited; we have a space 35 by 36 ft. and of this last dimension 20 ft. is devoted to the pump room. We can build as high as we wish.

At the present time we are operating two 72 by 16 by 30 in. engine driving a 150 kw. generator. During the day we fire with wood refuse from the shop; at night we use coal. Our present stack is 110 ft. high by 4 ft. diameter which will probably be too small for our future needs, but we can add on to it the necessary amount.

Would two 72 in. by 18 ft. horizontal return tubular boilers or one water tube boiler of the same capacity be best suited for our needs? W. C. F.

Packing for Oil Lines

WILL YOU kindly advise me as to what material is suited for a flange packing on an oil line? We have had considerable trouble with leaky joints on gasoline and kerosene pipe lines. The threads are well cut and the coupling and flanges carefully screwed on, yet there is a leak somewhere. A. A. N.

A. Flange joints on oil or gasoline lines are usually put together with thin sheets of tar paper or hard graphite impregnated asbestos gaskets and the joint is pulled up as tight as possible. Where leakage occurs through the threads, it is sometimes the practice to caulk the end of the thread against the inside of the flange. Good shellac is impervious to gasoline and is frequently used on the threads to prevent leakage at this point. Wherever possible flange joints are avoided, a simple screw coupling is found to give more satisfactory service for the majority of permanent installations.

Steam Cylinder Lubrication

IN THE May 15 issue of Power Plant Engineering, on page 543, A. H. asks concerning the lubrication of steam engine cylinders. Perhaps the following may be of value to A. H., and any others who may be interested in lubrication.

Quantity of oil that should be fed to the cylinder of a steam engine depends upon a number of factors, such as, the size, speed, and whether a compounded or straight mineral oil is to be used. If the steam is wet, the tendency is to wash off the lubricant; but if the lubricant is compounded, that is, if it contains a small percentage of animal or vegetable oil, it will not so easily wash off as will a straight mineral oil. The reason is that the compounded oil emulsifies with the water of condensation in the cylinder, and forms a lathery lubricant that stays put. It has been found in practice that if a straight mineral cylinder oil is used where the steam is wet, about twice as much of it will be required to lubricate the parts, as compared with a compounded oil.

Not long ago, a European engineer of considerable experience gave me the following formula for the quantity of oil that may reasonably be fed to an engine cylinder. I may further say that the formula gives results that agree with my own practice and experience in the matter. If it errs at all, it does so on the side of safety.

When high grade, compounded cylinder oil is to be used, the quantity may be found thus:

$D \times S \times R.P.M. \times 0.0066 =$ ounces of oil per hour.

This formula may be used for engines that have a stroke of 2 ft. or more and run at more than 125 r.p.m.

When an engine has less than a 2-ft. stroke and runs at less than 125 r.p.m. the constant in the formula becomes 0.005.

In both of these formulas D is the diameter of the cylinder in feet; S, the stroke of the piston in feet, and 0.0066 and 0.005 are constants, as determined by experiments for the given conditions of size and speed.

Assume a Corliss engine, 16-in. diameter by 3.5-ft. stroke and running at 60 r.p.m. Let us further assume that a high grade compounded cylinder oil is to be used, supplied either by an hydrostatic, or a mechanical force feed lubricator, and that we desire to know how much oil should be fed to the cylinder.

In the example chosen, one of the dimensions is "over," namely, the stroke, and the other is "under," namely, the r.p.m., so we will compromise between the two formulas. From the first formula, the quantity required is $1.33 \times 3.5 \times 60 \times 0.0066 = 1.8$ oz. of oil per hour, and in the second one, $1.3 \times 3.5 \times 60 \times 0.005 = 1.36$ oz. of oil per hour. The average is 1.55 oz. of oil per hour, required.

For our purpose we may say that a pint of cylinder oil weighs in the neighborhood of 1 lb. or 16 oz. This

is not exactly correct, but we may use that relationship for our problem does not deal with nor require exact mathematics. Then, as we found that 1.55 oz. of oil per hour would be required for one cylinder, $16 \div 1.55 = 10.3$ hr. of continuous operation could be maintained with the expenditure of one pint of cylinder oil for that engine. We know from everyday practice that this is about right for satisfactory results.

Just how many drops per minute should be given to feed 1.55 oz. of oil per hour or one pint in say 10 hr. can only be found by experiment and trial. Probably four or five drops of oil per minute would meet the requirements of the cast illustrated. In the engine referred to by "A. H." in the May 15 issue, three drops of oil per minute is about right as answered.

If a straight mineral oil were to be used, and if the steam were wet, and more frequently than not it is wet, then about twice the quantity of oil would have to be used to do the same work as when a compounded oil would be used. However, in any and all cases, use as little cylinder oil as possible, consistent with safety in maintaining a lubricating film between the moving parts, and a piston seal.

Brooklyn, N. Y. C. J. MASON.

Yearly Coal Consumption

ON PAGE 494 of the May 1 issue of Power Plant Engineering, A. P. W. inquires how to figure the amount of coal that will be required to operate his plant for a year. In order to answer the question, it will be necessary to assume a number of conditions concerning which no information has been given.

In the first place, the water rates of the prime movers will vary with the load and the efficiency of the boiler will vary with the steam demand, but for the purpose of the problem we may arbitrarily assume these conditions as being constant. Let us say, then, that 25 hp. will be required for the ice plant, that the steam consumption of the prime movers will be 30 lb. per hp.-hr. and that the steam pressure and feed water temperature are such as will give a factor of evaporation of 1.00; the heat supplied to the steam is 970.4 B.t.u. per lb.

The steam consumption then of the ice machine engine will be $25 \times 30 = 750$ lb. per hr., and steam consumption of the generator prime mover at 20-kw. load assuming 80 per cent mechanical efficiency will be $30 \times 20 \div 0.746 \div 0.80 =$ approximately 1000 lb. per hr. At 50 kw., the consumption would be 2500 lb. and at 5 kw., 250 lb. Thus the daily consumption of steam by the generating unit would be $1000 \times 12 + 2500 \times 250 \times 9 = 21{,}750$ lb.

During the time which the compressor is operating 24 hr. a day, the steam consumption will be $750 \times 24 = 18{,}000$ lb. per day and when it is operating only 12 hr. a day, it will be 9000 lb. per day. Thus the total consumption will be $21{,}750 + 18{,}000 = 39{,}750$ lb. of steam per day for 3 mo. of the year. For another 3 mo. of the year, it would be 9000 lb. less than this or 30,750 lb. per day. For the remaining 6 mo. of the year when the compressor is not in operation, it will be 21,750 lb. per day.

If we assume that the coal used has a heating value of 12,000 B.t.u. per lb., and that it can be burned with an efficiency of 65 per cent, it will be seen that for every pound of coal burned the heat realized in steam will be $12{,}000 \times 0.65 = 7800$ B.t.u. per lb of coal. As each pound of steam generated represents 970.4 B.t.u., it will be seen that for every pound of coal burned we can generate $7800 \div 970.4 = 8.04$ lb. of steam.

For 3 mo. of the year, then, there will be required $39{,}750 \div 8.04 = 4950$ lb. coal per day; for the other 3 mo. period, $30{,}750 \div 8.04 = 3830$ lb. per day; and for the 6 mo. period, $21{,}750 \div 8.04 = 2710$ lb. per day. Expressed on a tonnage basis, this is 2.475 T. per day for 3 mo., 1.915 T. per day for 3 mo., and 1.355 T. a day for 6 mo. On a basis of 30 days to a month, this means that the coal consumption will be $90 \times 2.475 = 222.75$ T. for 3 mo., $90 \times 1.915 = 172.35$ T. for 3 mo., and $180 \times 1.355 = 243.90$ T. for 6 mo. Adding these three quantities it is seen that the yearly coal consumption will be 639 T.

Rate of Evaporation from a Water Surface

IN ANSWER to the question by A. P. W. in the May 1 issue on page 494, concerning the rate of evaporation from a water surface the following may be of interest.

As ordinarily figured, the rate of evaporation from a body of still water in still air is given by the equation

$$W = (243 + 3.7\,T)\,(P - P\,M) \div 7000$$

Where W is the evaporation in pounds per square foot of exposed surface per hour; T, the temperature of the water; P, the vapor pressure at the existing air temperature (as found from a steam stable), and M is the per cent relative humidity, expressed as a decimal.

It will be seen from this equation that the moisture content of the air has a great deal to do with the rate of evaporation and as no value for this quantity has been given one will have to be assumed; say 75 per cent average relative humidity. In the problem T is given as 155 and P, corresponding to a temperature of 50 deg. is found to be 0.178 lb. per sq. in. Substituting these values we have

$W = (243 + 3.7 \times 155)\ (0.178 - 0\text{-}178 \times 0.75) \div 7000 = 817 \times 0.0445 \div 7000 = 0.0052 =$ lb. per sq. ft. per hr. As the tank diameter is 5 ft. the water surface is $0.7854 \times 25 = 19.6$ sq. ft. and the total evaporation is $19.6 \times 0.0052 = 0.102$ lb. per hr.

Inasmuch as the air over the tank is probably not still, the evaporation will be increased. For an average wind velocity of 8 or 10 mi. per hr. the evaporation will be increased about 8 times or to $8 \times 0.102 = 0.816$ lb. per hr. As the heat of evaporation of water at a temperature of 155 deg. F. is 1004.5 B.t.u. per lb., the heat lost is $1004.5 \times 0.816 = 820$ B.t.u. per hr.

To find the radiation losses, it may be assumed that the coefficient of heat transfer through the steel tank will amount to perhaps 3 B.t.u. per sq. ft. of exposed surface per degree difference in temperature per hour. As the tank diameter is 5 ft. and as the water stands at a depth of 5 ft. the exposed area is $3.14 \times 5 \times 5 = 78.5$ sq. ft. The temperature difference is $155 - 50 = 105$ deg. The radiation loss is then $105 \times 78.5 \times 3 = 24{,}800$ B.t.u. per hr.

In the case of the wood stack, the coefficient of heat transfer will probably not exceed 0.02. As compared with the steel tank then, the heat loss will be $0.02 \div 3 \times 24{,}800 = 165$ B.t.u. per hr.

POWER PLANT ENGINEERING

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Design of Motor Control Apparatus

One of the most important factors to be considered in the operation of electric motors is that of providing proper starting and stopping conditions. The current through the armature of an electric motor is not governed by the ohmic resistance of the circuit, but by the counter electromotive force, which is a function of the speed. Care must, therefore, be taken to avoid impressing full line voltage on the machine until the armature has accelerated sufficiently to prevent an excessive flow of current.

Electric motors are, as a rule, designed only with reference to their running conditions. Starting and stopping conditions must be taken care of by providing starting boxes and controllers which limit the armature current to a safe value during the periods of acceleration.

For this reason, especially in the case of large motors, the design of the controller or starter is an important point, and considerable care must be exercised in order to produce a device which will at all times protect the motor. There are three primary questions involved in the determination and layout of proper accelerating resistors. These are the total amount of resistance to be provided, its subdivision into steps, and the allowable current and thermal capacity of the conductors.

Readers having difficulty in solving problems of this type will, therefore, be interested in the article on this subject by Gordon Fox, which appears in the pages of this issue. Mr. Fox not only discusses the functions and principles of direct current controllers, but also explains in detail methods for determining and laying out accelerating resistors. Information upon this branch of electrical engineering is meagre and what there is of it is scattered throughout the literature in such a way as to render it difficult of access. In preparing this article, therefore, Mr. Fox has made a valuable contribution to electrical literature and has placed within easy reach the essential points of a somewhat perplexing subject.

Spend to Save

Many power plants will not stand even a casual inspection. They operate as evidence that somewhere along the line of ownership and management there is a lack of understanding of the savings that can be made through the expenditure of moderate sums for first grade supplies and time saving equipment.

Cracks in boiler settings, warped fire doors, inoperative dampers, steam and water leaks are proof that indifference or neglect prevails. The problem is to find those responsible for these conditions and then drive home the facts in each case.

Plants as pictured above do not generally exist because the engineer on the job is negligent or ignorant; for invariably it will be found that his actions indicate that he is physically fit, his clothes show that he is the kind of man who gets right into the job and a brief conversation will prove that he is experienced and knows his business.

Where, then, can the responsibility be placed? In any number of cases it is the fault of the management because the engineer, always a busy man, is not provided with first grade supplies and time saving equipment and instruments. The engineer is too often

spending much of his time in a fight to keep the plant operating at any cost rather than exercising his ability to improve general conditions and the economy of the plant. His job is made one of physical endurance rather than that of capitalizing for his employer through the use of his experience and brains.

Such equipment as feed water regulators, flow and temperature records are time savers for the engineer. Packing and general supplies should not be purchased through the office on price considerations only. Consult the engineer and profit by his experience, for in this way the cost of supplies will be reduced; many hours can be saved both on maintenance and operation, with the result that the engineer will have time to study and effect worth-while economies.

You can profitably spend to save.

Politics vs. Engineering Economics

Detroit is to have a municipal plant to supply the power for operating its municipally-owned street railway system. That is a simple enough statement in itself and yet it involves fundamental considerations which give rise to questions of exceedingly great importance.

Where a city, such as Detroit, is supplied with electric service by a highly developed, commission regulated public utility, is the city justified in going into the power business? If the city goes into the business of producing power should there be an interconnection with the utility and an interchange agreement which will reduce the reserve capacity of both systems?

Detroit has been definitely committed in the affirmative to the first question. Much might be and has been said relating to this decision. The Detroit Edison Co. after the first question had been settled came forward with an interconnection proposal which would have reduced the reserve capacity of the municipal plant by 20,000 kw. This offer was rejected by the city council.

With all of the advantages to be gained by the interchange of power through the increased diversity of load, such a decision appears to be a step backward. It would indicate either that the people of Detroit do not have confidence in their electric utility or that the subject furnished political capital.

Surely the time has come when our utilities, regulated as they are by the people, should have the confidence of the communities in which they operate. With that confidence established then the only considerations involved in such projects should be those raised by engineering economics and not the beclouding issues of party politics.

Off Duty

Vacation time is drawing near and many of us are looking forward to a more or less extended "Off Duty" period, during which we hope to leave our business worries behind and give ourselves up to "enjoyment unrestrained." The manner in which we accomplish that end will depend largely upon individual circumstances. Some will telegraph the head chauffeur at the winter residence in Pasadena to drive the Rolls Royce up to the Canadian Rockies, and then calmly follow along in a special train. Others will give the old tin Lizzie a new coat of paint, crank her up, and spend one or two enjoyable weeks amid the glorious discomforts of camp life. Still others, not so fortunately situated as to be able to afford the luxury of a week off, will look forward to pleasant week-end visits to the parks and playgrounds of the home town.

Regardless of our social or financial status, the amount of enjoyment which we derive from our summer vacation, or for that matter from any "Off Duty" period, depends largely upon what we make it. We cannot all go to the Canadian Rockies, nor would we find it desirable to do so. The owner of the tin Lizzie is not perhaps entirely unaware of its rattles; but he does not allow that fact to spoil his vacation—indeed not, he finds great satisfaction in knowing that his little three-hundred-dollar bus "gets him there" just as well as would the big six thousand dollar Pierce Arrow which, although it may go a little faster and ride a little easier, is subject to the same speed laws. After all, what difference do a few jolts make? "They aid digestion," says the flivver owner, and to substantiate that fact, he eats a man's size lunch when dinner time rolls around. In other words, he is an optimist, and probably regards the jolts on the road through life in the same way. He may never rise to the Pierce Arrow or the Rolls Royce class, but that will never dampen his spirits nor dispel his optimism.

As far as happiness is concerned, it makes little difference whether we journey through life in a Pierce Arrow or rattle through it in a tin Lizzie. In the equation of life, happiness is not a function of wealth or social prestige, and no juggling of the terms can make it so.

The story goes, of the astute Emperor Ho Hen, who returning to his palace from a late wandering induced by his inability to sleep, discovered Poo Phish, the vagabond, snoring comfortably upon a pile of teakwood. "How is it, fool," asked the emperor in vexation, awakening him, "that you sleep so soundly on hardwood under unprotected skies, whereas I, on down, am unable to slumber?"

"Because, fool!" retorted Poo Phish, "I have nothing to lose but my sleep."

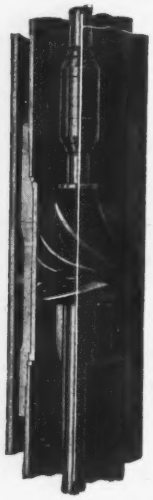
There is considerable truth in this bit of pseudo Japanese philosophy. Your happiness or your ability to slumber is not dependent upon your bank balance. Rather, it is dependent upon what use you make of the twenty-four precious hours at your disposal every day. Out of these twenty-four hours you have to spin health, pleasure, money, contentment and respect, and the right use of these hours is a matter of the highest urgency. Your happiness—that elusive prize that everybody is clutching for—depends upon the proper use of these twenty-four hours a day.

Arnold Bennett has written a little book upon this subject and has called it, "How to Live on Twenty-Four Hours a Day." Of course, there are a certain number of hours out of the twenty-four which must necessarily be given up to your daily work, and Mr. Bennett's book does not deal so much with this part of your "time supply" as it does with the remaining fourteen or sixteen hours. In other words, it deals with your "Off Duty" hours and if you want a bit of real inspiration or if you feel that you are not getting the most out of life, we earnestly recommend that you read this little book.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Propeller Type Impeller Used in Deep Well Pump

IN THE new type of deep well pump recently developed by the Worthington Pump and Machinery Corporation of New York City, a radical departure has been made in the type of impeller used. Although the pump is of the rotary class the water is not elevated by the



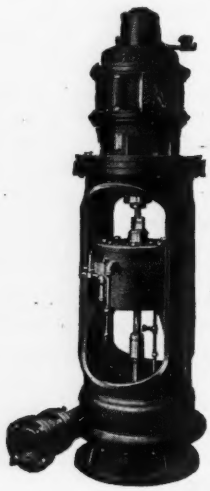


FIG. 1. DIFFUSION VANES JUST ABOVE PROPELLER WHICH CHANGE VELOCITY TO PRESSURE HEAD

FIG. 2. PUMP UNIT EQUIPPED WITH CENTRIFUGAL BOOSTER PUMP, SHOWN AT BOTTOM, AND THRUST BEARING SHOWN AT CENTER

conventional type of impeller but through the use of a propeller quite similar to that employed for propelling ships. The arrangement of this propeller together with the discharge vanes, the shaft, the shaft coupling and the bearing can be seen from a sectional view of a well casing and drop pipe shown in Fig. 1. These discharge vanes above the impeller receive the water and convert the velocity of flow into head and at the same time cause the water to flow upward smoothly along the axis of the pump.

In comparatively shallow wells, one set of impellers is used; but in deep wells, a number of impellers are necessary, these being placed one under the other, thereby making the pump equivalent to a multi-stage pump.

Where water must be elevated to a considerable height above the land level, a contrifugal booster pump is added and connected with the pump at the ground level. This combination gives one compact unit, the same as would be ordinarily obtained by using two pumps, one for deep well pumping and the other for above surface elevating. Figure 2 shows this centrifugal pump at the bottom with the discharge pipe emerging at the left. At the top is a standard vertical motor and midway between the bottom is shown the housing for the thrust bearing.

Impellers are made of hard bronze, capable of withstanding the corrosive action of the usual well water. The number and angle of impeller blades, together with their width and thickness vary with the conditions and are based upon calculations and tests which indicate the proper proportions for capacity and efficiency.

Thrust is taken care of by a three-plate self-adjusting type thrust bearing which takes the weight of the moving parts and the water column thrust. The top or plate thrust rotor is an iron plate which rotates with the shaft. In the center is a babbit faced bearing plate, the upper face of which is scraped to a true bearing surface with the top plate. The bottom plate or thrust washer supports the middle plate on a ball and socket seat.

The entire bearing runs submerged in oil and holes through the center plate allows the lubricant to pass to the cavity inside the plates, where it is picked up by the top plate and distributed through an oil groove arrangement to the bearing surfaces, between the top and middle plate. The oil bath is waterjacketed, a constant circulation of water being supplied by a small impeller attached to the pump shaft. The piping for water circulation is visible in Fig. 2. The self alining feature of this bearing and the fact that it runs submerged in a bath of water-cooled oil, materially reduce the attention required by the thrust bearing. In fact, the only requirement here is the periodic filling of the thrust casing with oil.

Simplicity Is Feature of New Autovalve Arrester

IN THE AUTOVALVE lightning arresters, illustrations of which are drawn herewith, the valve characteristics which have made the electrolytic arrester the outstanding protective device for large and important installations, have been secured and at the same time, the natural simplicity of the spark gap arresters and their freedom from the necessity for maintenance have been retained. The basis of construction is a unit consisting of a short spark gap between electrodes of considerable area, which are made of material of considerable resistivity. The resistivity of the electrodes forces the discharge in the gap to spread out over the area of the electrode, thus preventing the localization of the current and preventing the formation of hot spots. As long as

hot spots are prevented, the discharge does not become an arc, but remains in the form of a "glow discharge." The advantage of the glow discharge over the arc for such an application comes from several characteristics among which the most important is that the voltage across the discharge is practically constant regardless of current density and is comparatively high, approximately 350 v. By the use of insulating spacers in contact with the electrodes to establish the gap lengths, the break-down voltage of the gaps is also made approximately 350 v.

As a result of this construction, arresters using these gaps have the invaluable valve characteristics; that is, current does not flow until a predetermined voltage is reached, and for voltages above this value, the current is proportioned to the excess voltage. No current flows due to voltages below the predetermined critical value. When a short time excess voltage is applied current flows only due to the excess, and, assuming proper design by which the critical voltage is made higher than the voltage of the line to which the arrester is applied, after the surge oltage is relieved current flow ceases, that is, there is no follow of proper current.

This removes all the limitations in the reduction in the resistance to the flow of surge current which is imposed in the spark gap and resistance type of arrester.

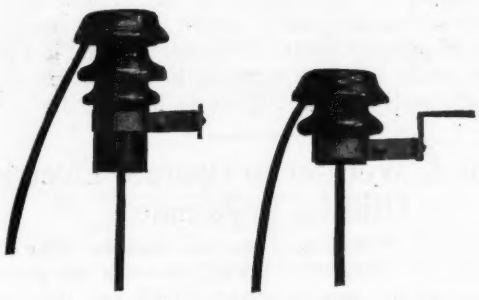


FIG. 1. VARIOUS TYPES OF AUTOVALVE ARRESTERS

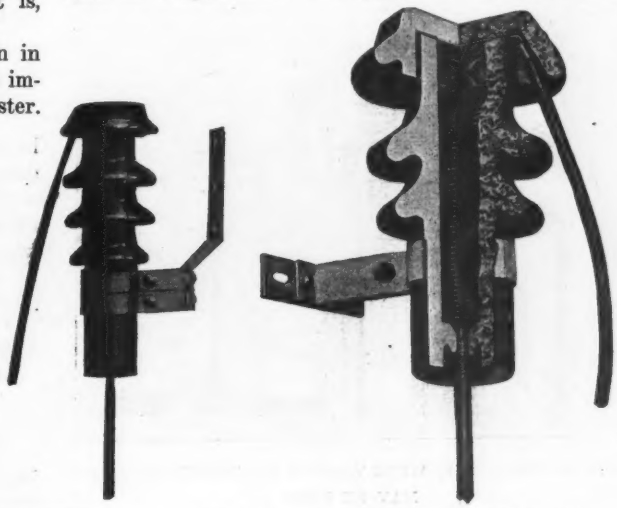


FIG. 2. CROSS SECTION OF 7500-V. ARRESTER

It is quite possible to provide arresters with resistance as low as desired, the only necessity being the use of electrodes of sufficient area.

Working parts of the autovalve distribution arresters consists of a column of flat circular discs, 1/8-in. thick and 2 in. diameter, separated by thin mica washers 3 to 5 mils thick. This column is connected between line and ground through a series spark gap. The number of discs is made directly proportional to line voltage. Discs and gap are enclosed in a porcelain casing with a line lead brought out at the top and a ground lead at the bottom. The arresters are arranged for mounting on cross-arms by means of galvanized steel mounting brackets. The brackets are arranged to permit mounting of the bracket alone on the cross-arm and assembly of the arrester in the bracket after it is mounted. The arrester is merely dropped into a ring provided in the bracket and a clamping screw tightened to secure it in place. To suit various connections, the arrester may be turned in the bracket to any angle desired.

Since it has been found that in many cases the amount of cross-arm room taken up by an arrester is of real importance, the mounting brackets for these arresters have been so made that the arrester may be mounted directly under the line wire, thus making it unnecessary to use up any of the valuable cross-arm room for the arrester. These arresters have been developed by the Westinghouse Electric & Mfg. Co.

New Plant Is Planned for Chattanooga

ULTIMATE capacity of 100,000 kw. is being provided for in the design of the new steam plant to be erected at Hale's bar by the Tennessee Electric Power Co., according to a statement of the power company. The project at Hale's bar already authorized by directors of the Tennessee Electric Power Co. calls for a 30,000-hp. steam plant, costing approximately $1,500,000.

The boiler room of the new plant will be 100 by 60 ft., and the turbine room 98 by 60 ft. The turbine will have 14 stages and will require 10 lb. of steam per kw.-hr., and under the average operating conditions will average 1.5 lb. of coal per kw-hr.

Steam required for miscellaneous uses such as vacuum pumps and feed water heaters will be obtained by bleeding the turbine at different stages. The condensed steam after leaving the air cooler will pass through a two-stage heater, taking steam from the seventh and eighth stages of the turbine. Outside of the vacuum pumps there will be no steam driven auxiliaries in the plant. Motor drive will be used for operating the condensate and boiler feed pumps, forced draft fans, induced draft fans, stokers and economizer scrapers.

It is reported that the turbine and generator have already been ordered and are promised for shipment in March of next year. Specifications are now being gone over for the boilers, condenser and other equipment. All of the equipment will be installed next spring, and it is expected that the plant will be ready for operation by the summer of 1924.

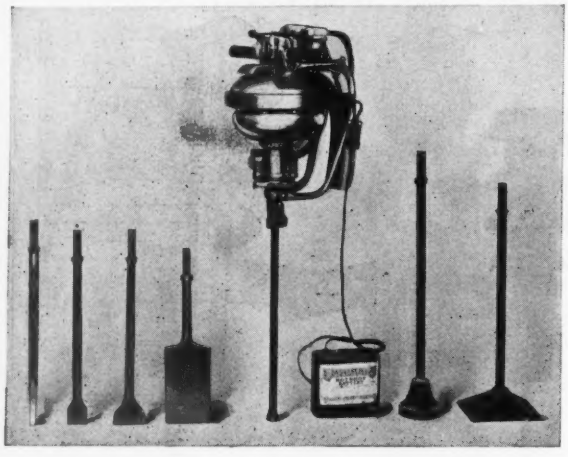
Additional power development being started this year calls for an expenditure of $3,670,000. Besides the

Hale's bar plant the program calls for a 20,000-hp. development at Great Falls costing $1,800,000 and the building of a new 120,000-v. line from Cleveland to Knoxville costing $370,000.

Portable Drill Is Driven by Gasoline Engine

WHILE the use of compressed air for drilling purposes is widely known and electrical power for such purposes has also recently been utilized, the use of a gasoline engine for a portable drill is somewhat of a novelty. The Pennsylvania Gasoline Drill Co., of Philadelphia, has, however, recently developed a drill operated by such power as shown in the accompanying illustration.

In the construction of this drill, the action of an air hammer and a gasoline engine is combined in such a manner that the drilling unit has but two moving parts,



GASOLINE DRILL UNIT WITH VARIOUS ATTACHMENTS WHICH MAY BE USED

the hammer piston and the flywheel assembly. No crank shaft or connecting rod is employed and there is no spring or other yielding member used in the internal construction. No inlet or exhaust valves or cam shafts are used, as the air and gas passages are fixed ports, cut through the solid steel of the cylinder.

Power strokes of the hammer piston are made with approximately 900 lb. of gasoline explosive force thrusting it forward to hit the drill bit. The flywheel is employed only to return the hammer piston on the upward or compression strokes. Approximately 1800 impacts are struck each minute. For carburetion, a gasoline mixing valve is used which permit the drill to be worked at any angle. While the drill continues to run at full speed the operator shifts it from one position to another and to any desired angle without affecting its operation. To start the drill the operator gives the rim of the flywheel a pull by hand. It will be noted from the illustration that a small gasoline supply tank is provided, this being carried on the back of the operator or set at one side as desired. The gasoline supply is under air pressure which allows the placing of the supply tank below the level of the engine. The weight of the unit is 70 lb.

Detroit Refuses Interconnection with Edison Co.

IN connection with the plans for the 80,000-kw. municipal plant which the city of Detroit has under way, the city council recently declined to concur in a recommendation of Alex Dow, president of the Detroit Edison Co., that an inter-connection with the lines of that company would reduce the reserve capacity needed at the city plant by one 20,000-kw. unit with a resulting saving of $3,500,000 in plant cost. At the same time, Mr. Dow pointed out that this saving would result in a reduction of power costs of $365,000 annually, due to decreased fixed charges and operating expense.

It was shown by Mr. Dow that the peak load of the Edison system would come at a different time from that of the city plant and that peak load power could be supplied to the city without increasing the facilities of the Edison Co. He suggested a rate of 1.3c per kw.-hr., subject to approval by the Michigan Public Utilities Commission, for current sold to the city on such a basis.

Detroit, as a result of the council action, will proceed with a $12,000,000 plant at the foot of Morrell street, a few blocks west of West Grand boulevard. Mr. Dow would have built the plant more centrally and have thus saved the cost of distributing power to the downtown section where the heavy load is now carried.

In failing to take action on the Edison chief's recommendation, the council agreed with the engineers who are to build the plant. The engineers said it would be more costly to produce power in a plant of three 20,000-kw. units than in the one to be erected.

Stone & Webster to Operate Electric Utilities in Jamaica

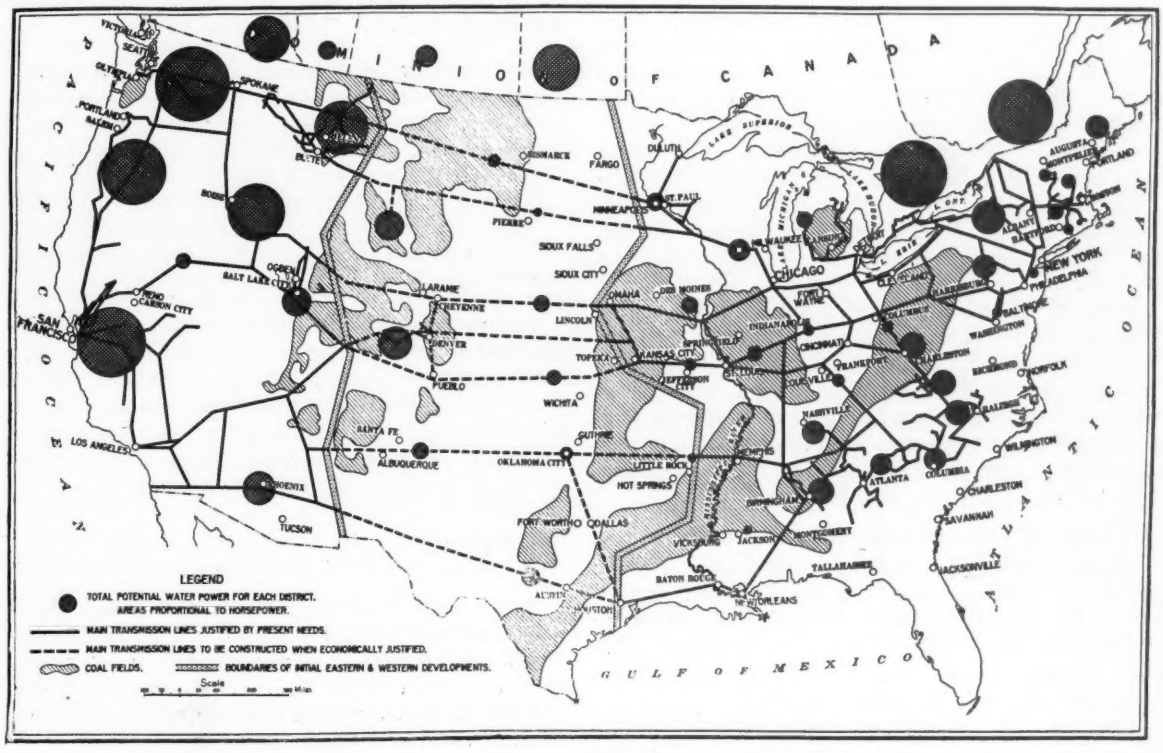
STONE & WEBSTER, Inc., of Boston, has been appointed by Montreal banking interests as general managers of the new company which has just been organized for carrying on the electric light and power and street railway business in Kingston, Jamaica, British West Indies. The financing of the new company, which is the Jamaica Public Service Company, Ltd., is being done by a syndicate headed by Greenshields & Co., and including Aemilius Jarvis & Co. and Mackenzie & Kingman, all of Montreal. The companies formerly operating in Kingston have been acquired by purchase. These include the West India Electric Co., Ltd., and the Jamaica Electric Light & Power Co., Ltd.

Kingston is the capital and largest city on the island of Jamaica, about 150 mi. southeast of Cuba. The new company will do the entire electric light and power and tramway business in Kingston and adjoining parishes of St. Andrew and St. Catherine, the territory having a population of about 125,000.

Alfred S. Nichols, who has been manager for the past 6 yr. of the Paducah Electric Co., Paducah, Ky., has been appointed manager of the Jamaica Public Service Co. Roy S. Nelson, formerly chief engineer of the Eastern Texas Electric Co.'s power station at Port Arthur, Texas, will take charge of the steam power station in Kingston and the hydroelectric station on the Rio Cobre, about 16 mi. from the city.

Electricity for All North America

ONE of the most far-reaching conceptions of modern times is shown in this map, prepared by Frank G. Baum, hydroelectric engineer, of San Francisco, which discloses a plan for a single electric super-power system to cover practically all of the United States and Canada. Though immense in its scope, it is nevertheless entirely practical with modern electrical apparatus, according to General Guy E. Tripp, Chairman of the Westinghouse Electric & Manufacturing Co., an advocate of this plan.



A SUGGESTED SUPER-POWER SYSTEM FOR NORTH AMERICA

"The chief reason for the existence of a single electric system," states General Tripp, "is that it will make available to the entire nation our resources of water power and coal. This system will provide North America with the maximum amount of power at the lowest cost, distribute it to the largest number of people, and conserve our fuel resources in the most effective manner. The single system is not only practical and desirable, but, in my opinion, essential to American progress."

WILLIAM C. FRYE, for seven years president of the Chain Belt Co., Milwaukee, has retired from active participation in its affairs and has been succeeded by C. R. Messinger, vice-president and general manager since 1917. Mr. Frye is retiring after an active association with the company for 28 yr. During this time he has occupied practically all the important executive positions and just previous to his election as president in 1916 was treasurer. Mr. Messinger, who succeeds Mr. Frye, became associated with the Chain Belt Co. in 1917.

Pacific Coast Electrical Men Discuss Power Problems

FROM eight Western and Pacific Coast states and British Columbia, America's great storehouse of hydroelectrical power, several hundred delegates assembled in San Francisco on June 19 to 22, for the seventh annual convention of the Pacific Coast Electrical Association. The various phases of electrical development, from the installation of power plants to the utilization of electrical power in fields, mines, plants and homes were gone into thoroughly by the delegates.

L. M. Klauber, of the San Diego Consolidated Gas & Electric Corporation, was elected president, succeeding James B. Black, of San Francisco. Other officers elected were: William Baurhyte, Los Angeles, first vice-president; Frank A. Leach, second vice-president, and S. B. Anderson, treasurer.

Following the San Francisco League luncheon, which was given over to the discussion of the progress of the electrical vehicle, the delegates opened their technical sessions. L. J. Moore, executive engineer of the San Joaquin Light and Power Co., presided over a meeting in which reports were presented by J. E. Woodbridge, H. Michener and O. A. Knapp, on various phases of power distribution advances made on the Pacific Coast during the year.

INTERCONNECTED TRANSMISSION FROM CANADA TO MEXICO

A super-electric power system to connect all of the major power lines on the Pacific Coast between Mexico and Canada into one tremendous distributing trunk-

line approaches an early completion was the statement made by D. C. Jackling, copper magnate, who is listed as the world's largest individual user of industrial electricity.

He stated that the eyes of the engineering world are turned toward the great utilities of the West in their record breaking hydroelectric developments and particularly so in regard to the inter-connecting of all major power lines. In his opinion, the electrical industry is a basic industry and a necessity for progress, but the giant of all is the superpower system of the Pacific Coast, which to date comprises the California power companies, two important Oregon utilities and Nevada lines. The northwest companies will join in on the system probably before the end of the summer. Then will exist a superpower system whose main trunk will be 1800 mi. long. If this system were to be transplanted to the Atlantic seaboard, it would serve a territory from Quebec, Canada, to Charlestown, S. C.

In a report submitted by President J. B. Black, it was disclosed that California is the greatest producer of hydroelectric energy in the United States. This leadership in the development of electrical energy, Mr. Black said, probably never will be relinquished by this state.

Without the initiative and resourcefulness of the electrical industry of California and on the Pacific Coast, resulting in the building up of a load of remarkable diversity, asserted Mr. Black, its developed water power resources would be only a fraction of its present total and the people of California would not be able to purchase as they now do, cheaper than in any other part of the world.

Electric Power Important for Irrigation

Electrical energy is playing a tremendous part in the agricultural development of the Pacific Coast, particularly in the pumping of water for irrigation, according to Professor Frank Adams, one of the speakers. Professor Adams is head of the irrigation investigation department at the University of California.

Gravity irrigation systems always have and always will supply irrigation water to the largest bulk of our irrigated areas, he said, although electrical pumping is taking up the slack, and, in a way, is measuring the growth of some of our most attractive areas. Electrical pumping also is making possible the profitable continuation of some of our gravity system irrigation work.

Governor Charles B. Mabey, of Utah, sounded a note of warning concerning the conservation of oil in California, pointing out that the way to save fuel oil is to substitute hydroelectric power wherever possible for power generated by steam or internal combustion engines.

A solution of the Colorado River problem was proposed by Governor James G. Scrugham, of Nevada, who mentioned his suggestion for the first time at the conference. The proposal is that the states of California, Nevada and Arizona form a combination and go forward with the projects planned to utilize the vast power and irrigation possibilities of the river.

Governor Scrugham, who is an engineer of international reputation, declared that the Colorado River is a menace to the Imperial Valley and that unless its waters are placed under control, the time will come when a disaster accompanied by great loss of life will occur. The proposed treaty concerning the waters of the Colorado is held up by a deadlock because of the refusal of Arizona to become a party to it.

News Notes

Elliott Co., Pittsburgh and Jeannette, Pa., announce the following changes in its sales organization: M. C. Sickels, formerly district manager of the Cleveland office, is now in charge of the Chicago office. C. H. Swett, who has been connected with the Philadelphia office for a number of years, becomes district sales manager of the Cleveland office. These changes concern also the sales work of the Liberty Mfg. Co. and Lagonda Mfg. Co., subsidiaries of Elliott Co.

W. C. Finely, erecting engineer for the Pelton Water Wheel Co., is at Ocean Falls, B. C., where he is installing a 6300 hp. Pelton double-overhung reaction turbine at the power plant of the Pacific Mills, Ltd. The new turbine is of the same general design as the three Pelton units installed for the company 4 yr. ago. These have a capacity of 8700 hp., which, when the new turbine is installed, will give a total of 15,000 hp., supplying all the power required for the company's pulp and paper mills.

Increased volume in the steel business is reflected in the construction program of the Carnegie Steel Co. at its Munhall, Pa., plant. Eight new 834-hp. Stirling boilers and eight Westinghouse underfeed stokers will supply steam for steel production. The new stoking equipment includes steam power refuse dumping mechanisms, non-clinkering extension sidewall tuyeres and automatic secondary ram fuel bed control adjusting mechanisms. Engberg vertical steam engines will drive forced draft fans. This plant uses Pittsburgh coal.

Mr. Samuel B. Flagg has become associated with the the anford Riley Stoker Co. as special representative at New York City. Mr. Flagg was engaged for several years in fuel studies with the United States Bureau of Mines and for the past six years has been associated with the Electric Bond and Share Co. as fuel expert.

North Missouri Power Co., of Brookfield, are installing a 350 hp. Stirling boiler equipped with Illinois forced draft chain grate stokers and a 1250 kw. Westinghouse turbine with Westinghouse condenser.

Stone & Webster, Inc., of Boston, Mass., has leased the second, third and fourth floors in the building at 28 Oliver street, Boston, to provide for expansion in the company's office work.

The A. W. Cash Co., of Decatur Ill., announces the appointment of the Ashmead-Danks Co., 7016 Euclid Ave., Cleveland, O., to represent the company in the Cleveland territory.

Midwest Steel & Supply Co., Inc., 100 E. 45th St., New York, has changed its title to Midwest Air Filters, Inc.

P. J. Freeman, formerly engineer of tests with the Pittsburgh Testing Laboratory, announces the opening of offices for general consulting engineering at 311 Ross street, Pittsburgh, Pa.

F. M. Feiker, formerly vice-president of the McGraw-Hill Co., and more recently on leave of absence as special agent to the Department of Commerce at Washington, will be associated with the staff of the Society of Electrical Development of New York City.

Atlantic Tar & Chemical Works, Ltd., of Elizabeth, N. J., has let a contract for the construction of a complete 700-hp. boiler house. Springfield boilers are being installed and Ballard-Sprague Co. has been awarded the contract for the brick stack and boiler settings. V. Weaver Smith is the designing engineer.

Uxbridge Worsted Co., of Uxbridge, Mass., will construct a new power plant for its mills, for which plans have been prepared by George P .Carver, Inc., of Boston. The plant will be 50 by 55 ft., one story, brick, with three water tubes, coal fired boilers capable of developing 1500 hp. The plant is to be completed by early fall.

Blackstone Valley Gas & Electric Co. and the Pawtucket (R. I.) Gas Co. will make extensive improvements in its plants and distribution service which are expected to involve an expenditure of about $2,000,000. The increased output has necessitated enlarging the main plants of the companies on Tidewater street, Pawtucket, and additional buildings will be constructed which will double the present output of 3,750,000 cu. ft. of gas per day. New boiler equipment will be installed to increase the output of the generator plant which will necessitate the building of an addition to that plant.

Montana Power Co. has awarded a contract to the Pelton Water Wheel Co. for furnishing two 7500 hp. single-runner, single-nozzle impulse turbines for the first unit of its Mystic Lake, Montana, development. These turbines will operate under an average effective head of 1050 ft. and will embody various features such as auxiliary relief needle nozzles and direct-motion governors. The contract includes two hydraulic-cylinder operated gate-valves at the power house and a butterfly valve at the head of the penstock. The latter will be equipped for electric-motor and hand-operation, and for direct and remote control.

Metropolitan District Commission, of Boston, has awarded contractss to Starkweather & Broadhurst, Inc., of Boston, Mass., for installation of one of the largest centrifugal pumps ever installed in New England, to be located in the Ward street sewage pumping station in the Back Bay district of Boston. The pump will have a capacity of 50,000,000 gal. of screened sewage per 24 hr. against a pressure of 20 lb. per sq. in. The capacity of the pump is equivalent to 35,000 gal. or 150 T. of sewage per minute. The weight of the pump and driving engine will be about 100 T., so that it will deliver its own weight in sewage every forty seconds. The pump will have a 36-in. diameter discharge opening and 42-in. suction opening and the delivery will make up a full capacity stream for a pipe 4 ft. in diameter. The pump will be driven by a direct connected steam engine of the Uniflow design, of high economy.

An electric generating system was authorized by the public service commission to be included in the new power plant to be constructed for Purdue University. The 1923 session of the General Assembly appropriated $275,000 for construction of the power plant, but provided that an electric generating system could be included only on approval of the public service commission. An investigation by Earl Carter, chief engineer, convinced the commission the university could produce electric current cheaper than buying it. The Legislature made a similar power plant appropriation for the Riley Hospital, Robert W. Long Hospital and the Indiana University School of Medicine in Indianapolis. The generating system at the university was authorized last week.

Four General Electric Company officials were recently given honorary degrees at four important American Universities this week. Gerard Swope, president of the company, was awarded the honorary degree of Doctor of Science at Rutgers College on June 12. Owen D. Young, chairman of the board of directors, was given the degree of Doctor of Literature at St. Lawrence University, of which he is an aluminus, on June 12, while Dr. Irving Langmuir, assistant director of the research laboratory, received the honorary degree of Doctor of Science from Union College, Schenectady. David B. Rushmore, consulting engineer, was given the B.S. degree from his alma mater, Swarthmore College. All of these men have been intensely interested in furthering scientific education in our colleges and schools and have taken a leading part in the forward looking movement of co-operation between the colleges and industry.

U. S. Civil Service Commission announces an examination for Electrical Draftsman (Design), receipt of applications to close Aug. 7, to fill a vacancy in the Bureau of Yards and Docks, and vacancies in positions requiring similar qualifications in that Bureau and other offices of the Navy Department, at entrance salaries ranging from $6.80 to $8.80 a day, plus the increase of $20 a month granted by Congress. Duties consist of laying out and developing work completely from preliminary instructions, determining the design and computing its sufficiency. Appointees must have executive ability and be capable of directing a force of draftsmen; must be capable of performing the highest grade of drafting in the particular line in which application is made and of making all the complex engineering calculations pertinent thereto. Competitors will be rated on education, training and experience.

U. S. Civil Service Commission announces examinations for Valuation Engineer, $3600 to $4800 a year, and Associate Valuation Engineer, $3000 to $3600 a year. Applications will be rated as received until Aug. 31. The examination is to fill vacancies in the Technical Staff of the Income Tax Unit of the Bureau of Internal Revenue, Treasury Department, and in positions requiring similar qualifications. The duties of these positions involve the estimation of the quantity of oil and gas, coal or timber, in place; the theoretical and market values of oil and gas, coal or timber in place, and their products; the value of equipment ordinarily used in the discovery, exploitation, and utilization of such natural resources; and the cost of development, exploitation, and utilization of such resources. In addition, a general knowledge of the processes and conduct of the industry will be required. Competitors will not be required to report for examination at any place, but will be rated on their education, training, and experience.

Catalog Notes

STRONG STEAM SPECIALTIES are covered in catalog No. 26, which is now being distributed by the Strong, Carlisle & Hammond Co., of Cleveland, Ohio. The specialties described and illustrated cover steam traps, the Strong method of boiler feed regulation, separators for oil and steam, vacuum traps, pump governors and pressure regulators, engine stops, together with the various valves built by this organization.

LOW PRESSURE VACUUM EVAPORATORS, a reprint of a paper delivered by Commander C. A. Jones and Lt. Commander A. M. Charlton, U. S. N., before the American Society of Naval Engineers, is being distributed by the Sugar Apparatus Mfg. Co., of Philadelphia, Pa. The discussion in this paper covers the use of evaporators in the navy and shows the results of some experiments conducted with the Lillie evaporator for such service.

"ZERO" OR ONE AND ONE-HALF—WHICH? is the title of a booklet now being distributed by the Graver Corporation, of East Chicago, Ind. This booklet takes up the problem of water softening and the kind of system best adapted to steam power plants. Comparative merits of the Zeolite and hot process are discussed. Since the Graver organization builds several types of water softening equipment, the subject matter is handled from the general engineering viewpoint without apparent bias.

BETHLEHEM-WEIR PUMPS for Boiler Feeding and Other Duties are discussed in catalog WC issued by the Bethlehem Ship Building Corporation, of Bethlehem, Pa. Beside the discussion of mechanical details there is also considerable information given on the flow of oil in pipes in which tables and curves are used to show the results of an extensive series of experiments to determine the loss of heat due to the flow of all classes of fuel oils.

"A COMPLETE Treatise on the Subject of Oil Burning" is the title of a new catalog of Quinn fuel oil burning equipment, recently issued by the Combustion Engineering Corporation, New York. This is a 32-page illustrated booklet and contains a great deal of useful information of the subject of burning fuel oil.

In the first part of the book is presented several articles relative to the properties, specifications, advantages, and the supply of fuel oil. The latter part of the book is devoted to articles on the installation and operation of fuel oil burning systems. A complete test on a Quinn oil burner conducted in the boiler plant of a large oil refinery is also described in this book.

VICTORY MFG. CO., of Niles, Calif., announces a new catalog descriptive of Victory double packed stop cock valves.

MULTIPLE RETORT ADVANTAGES in a Side Cleaning Stoker, is the title of a folder now being distributed by the Sanford Riley Stoker Co., of Worcester, Mass.

BROWNHOIST SINGLE ROLL COAL CRUSHERS are described in catalog F recently issued by the Brown Hoisting Machinery Co., of Cleveland, Ohio. The bulletin shows the mechanical details of this crusher and gives the dimensions for the various sizes.

CONVEYORS CORPORATION of America, Chicago, Ill., has just issued an 8-page booklet, "Representative Installations." The booklet contains illustrations of a number of notable buildings and power plants which are equipped with the company's American Steam Jet Ash Conveyor.

OIL BURNING IN POWER PLANTS is the title of a booklet published by the National Airoil Burner Co., of Philadelphia. Details of the burners made by this organization are shown and the particular merits discussed. There is also a chart for calculating the contents of partly filled horizontal and cylindrical tanks.

WOOD PIPE is the title of a new catalog, No. 18, recently issued by the Continental Pipe Manufacturing Co., of Seattle, Wash. It pictures and describes many noteworthy installations of wood stave pipe lines and in addition contains a very comprehensive treatise on hydraulics and the flow of water in both open and closed channels.

HOLOPHANE GLASS CO., Inc., 342 Madison Avenue, New York, N. Y., has issued a twelve-page illustrated booklet describing the new Holophane Lightmeter. This booklet shows the details of construction of the Lightmeter and gives instructions in its use and should be of particular interest to electrical engineers of central stations and municipal engineers.

METHODS OF PROTECTING Underground Pipes Against Radiation Losses are described in a number of bulletins bound in one cover and entitled the Ric-Wil Method, issued by the Ric-Wil Co., of Cleveland, O. The scheme employed is the use of special sectional tile with arrangements for supporting one or several pipes and then filling around them with packed insulating filler.

CONTROL RELAYS, to be interposed between the circuit breaker solenoid and control switches, are described in bulletin No. 47672 issued by the General Electric Company. The relays described are known as the Instantaneous Control, type PB-53, and the Hesitating Control, type PB-54. These relays are used for the remote control of circuit breakers when it is undesirable to have the control current pass through the control switch.

Both types operate by means of a plunger. The control circuit of the breaker is made by closing the relay contacts. Only the small current necessary to energize the relay coil is passed through the control switch. The hesitating control relay is used to provide the necessary time delay that is required, so that the circuit breaker may be fully closed and latched before its closing circuit is interrupted.

HANNA RIVETERS is the subject of a folder issued by the Hanna Engineering Works of Chicago, Ill. The riveters described range in capacity from 15 T. to 100 T.

HEINE BOILER CO. of St. Louis, Mo., is distributing a folder which describes the experience over a 5 yr. period of the Robert Gair Co. of Haverhill, Mass., with Heine boilers.